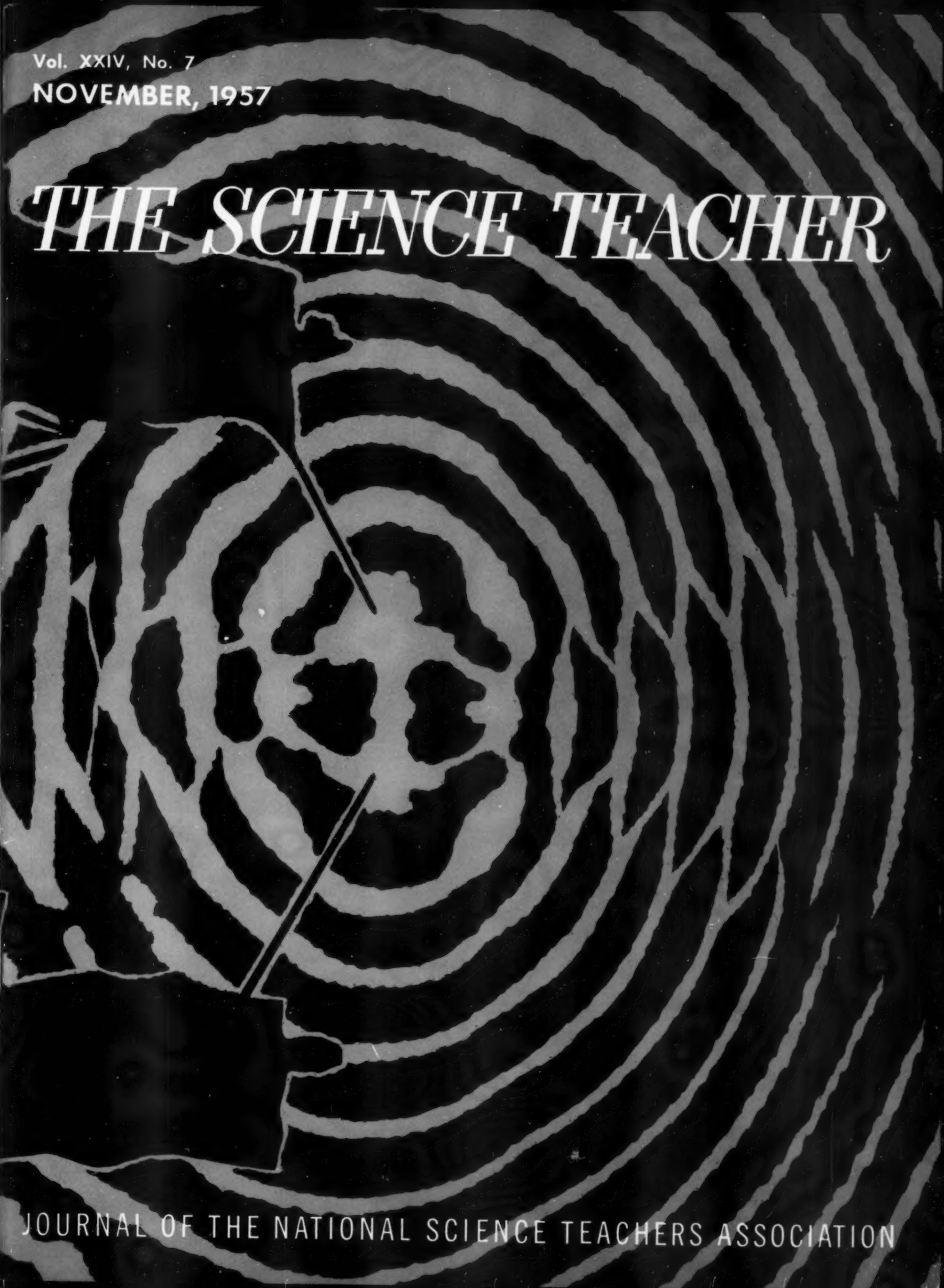
Vol. XXIV, No. 7
NOVEMBER, 1957

THE SCIENCE TEACHER



JOURNAL OF THE NATIONAL SCIENCE TEACHERS ASSOCIATION

Sheldon Total Experience Science Laboratory

THE HARCOURT, BRACE SCIENCE PROGRAM

THE SCIENCE TEACHER

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The National Science Teachers Association is a department of the National Education Association and an affiliate of the American Association for the Advancement of Science. Established in 1895 as the NEA Department of Science Instruction and later expanded as the American Council of Science Teachers, it merged with the American Science Teachers Association and reorganized in 1944 to form the present Association.

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THE SCIENCE TEACHER

The Journal of the National Science Teachers Association, published by the Association monthly except January, June, July, and August. Editorial and executive offices, 1201 Sixteenth Street, N. W., Washington 6, D. C. Of the membership dues (see listing below), $3 is for the Journal subscription. Single copies, 50¢. Copyright, 1957 by the National Science Teachers Association. Entered as second-class matter at the Post Office at Washington, D. C., under the Act of March 3, 1879. Acceptance for mailing at special rate of postage provided for in the Act of February 28, 1925, embodied in paragraph (d), Section 34.40 P. L. & R. of 1948. Printing and typography by Judd & Detweiler, Inc., Washington, D. C.

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- Where Is the Science in Science Education?
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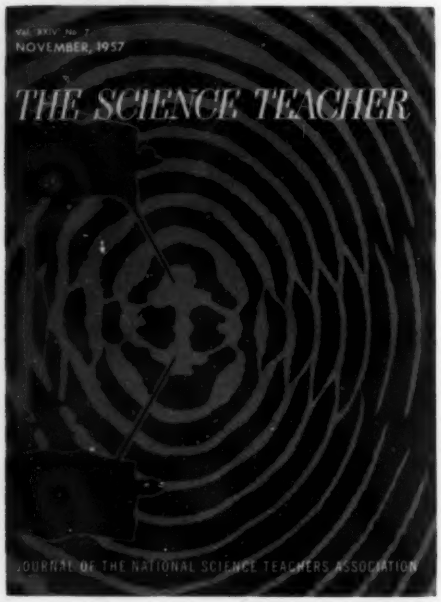
- On Behalf of Archimedes
- Identifying Future Scientists
- The Rationality of Some Intuitive Foundation Stones

THIS MONTH'S COVER



is a design suggested by the ripple tank, a device for producing continuous waves which simulate light waves. Their characteristics and behavior can be studied under controlled conditions. Apparatus components which are variable under the control of the student make possible the production of waves of differing frequency, reflections or echo patterns, interference patterns, and diffraction.

The cover design emanates from an interference pattern in the ripple tank developed by the Physical Science Study Committee, whose plans, achievements, and prospects are discussed in four articles in this issue of *TST* as a special feature of this month's journal (beginning on page 315). The ripple tank is but one example of a key purpose of PSSC—to design or redesign equipment for physics students which can be easily built in the school and at low cost. In addition to its low cost, this type of equipment will enable students to explore the very frontiers of science on the same kinds of problems that attract the attention of the world's leading physicists.

One of the major accomplishments of PSSC to date is publication of an experimental physics textbook, the first of four to be produced. It is available in limited quantities at $2.50 per copy. It is designed for study by teachers rather than for classroom use at this time. Copies may be obtained by writing to the Physical Science Study Committee, Massachusetts Institute of Technology, Cambridge 39, Massachusetts.

Editor's Column

Continued deep concern, financial support, and action programs for the extension and improvement of precollege science teaching are heartening to teachers and others who have responsibilities in this area. The editors of *TST* are privileged and pleased to devote much of this issue to a report on one of the most significant of such projects—the Physical Science Study, headquartered at the Massachusetts Institute of Technology.

PSS enjoys active participation of high school teachers and Nobel prize winners, among others. It is being lavishly supported by nearly $750,000 from the National Science Foundation, $500,000 from the Ford Foundation, $250,000 from the Alfred P. Sloan Foundation, and $200,000 from The Fund for the Advancement of Education. In addition to promising a high school course of new design, PSS portends an impact which is likely to be felt in new or revised textbooks and syllabi for the "standard" high school physics course.

The underlying hypotheses and the goals of PSS seem to have important implications for other segments of the curriculum in science for grades one through 12. But certain questions arise which perplex both the teacher and curriculum worker.

This study urges us to stress fundamental, or "pure," physical science and to leave out most of the applied science, the engineering, the technology, and the "gadgetry" which now comprise such a large part of physics and chemistry at the high school level. Is this advice also to be applied to high school biology? How about junior high school general science—and science in the elementary school? At the same time that PSS is urging us in one direction, other well-meaning friends among the engineers and industrial scientists are asking for more and better treatment of their problems and concerns in high school science, which means, of course, technology and applied science; it means refrigerators, and polio vaccine, and sputniks. If all or most of this kind of "science" is omitted from high school physics, biology, and chemistry, when and where, if at all, should it be provided in the training of the engineer or industrial scientist?

It is an honor and a privilege for me to serve as a member of the PSS Steering Committee. I look upon the study *as an experiment*, certainly the boldest and the most promising venture in high school physics in half a century at least. In discussions and deliberations of this committee, I have tried to represent "the high school teacher" and have urged a heads-in-the-stratosphere, feet-on-the--ground approach. But I feel the need for more advice; I think the rest of the committee would also welcome reactions and suggestions. In the final analysis, both the revolutionary approach of this study and the value of its impact upon science teaching must be measured by the reactions it invokes.

I hope many of you will be impelled to read about, think about, and write about PSS.

Robert H. Carleton

Readers' Column

Just received my copy of the revamped *Elementary School Science Bulletin*. Such an improvement!

R. J. CHINNIS
Rockville, Maryland

Enclosed is the six dollars for my membership. I do not mind the change in price. The membership is worth that much and more.

SISTER M. CHARLOTTE
Sisters of the Holy Cross
Los Angeles, California

Most, if not all, of the groups of which I am an officer have raised their dues. NSTA is well worth the increased dues, I feel, since there is so much volunteer activity and particularly in view of the vast, tireless efforts of the headquarters staff.

L. REED BRANTLEY
Department of Chemistry
Occidental College
Los Angeles, California

As a prospective science teacher, I have enjoyed reading your journal because it is not only interesting but also stimulating in connection with some of the courses I am taking in school. As I should like to take out my own subscription to the journal, would you please advise me about student membership.

URSULA M. SACHSE
Pennsylvania State University, University Park

I found the Association's address in a booklet on "Science Teaching Techniques" (published in Great Britain). I would like information on how we in South Africa can subscribe to *The Science Teacher* and become a member of your Association so as to receive regular packets of science teaching aid materials.

J. PAPENFUS
Brits High School
Brits, Transvaal
Union of South Africa

I have wandered far afield since joining the Association in Seattle last year. I had the opportunity to serve in this small private school for one year under the auspices of the Department of State. It is a challenging assignment. The American School is establishing high school work this year and I am called *the* high school mathematics and science instructor. My laboratory is

the bathroom of a former sultan's palace here in the city center. It would be far simpler to restore it than to adapt the quarters to their new use.

I profited from my membership in NSTA last year and am desperately looking for all the help I can get now. If it is possible to forward *The Science Teacher* and the packets to me here, they would be a great help.

William N. Shanks
The American School of Tangier
Tangier, Morocco

NSTA is maturing into a top professional organization in the education field. Best wishes!

Roger G. Olstad
Science Department
College of Education
University of Minnesota, Minneapolis

A comment concerning Mr. Trout's useful suggestion for surface tension determinations ("Surface Tension" by Verdine E. Trout, *Classroom Ideas,* October 1957 *TST*, page 285): The legend under Figure 2 includes the item "g—Value of gravity 980."

I fear that the use, even among teachers talking to teachers, of imprecise, short terms for *g* carries unwittingly into the classroom. The result is a vague and imperfect notion by the student of the important concepts of weight, acceleration, and so forth.

Why not be forthright and tell the student that gravity is a phenomenon, that the earth attracts a body with a force (the "force of gravity") called the weight of the body, and that this force causes the acceleration due to gravity (represented by g)? The need for correct units (of dimension LT^{-2}) then is clear.

A second comment is an addition to Mr. Drayton's ingenious method of salvaging stoppers and/or tubing ("Glass Tubing and Stoppers: You Don't Have to Fight Them" by Charles D. Drayton, Jr., *Classroom Ideas,* October 1957 *TST*, page 285).

I have found that rolling the stopper back and forth under light foot pressure for a few minutes will generally loosen even the most stubborn tubing. In fact, short lengths of glass (two or three inches) will migrate completely out of the stopper under this treatment.

R. R. Gates
Division of Sciences and Mathematics
Fullerton, California, Junior College

Before moving from Florida State University to East Texas State College (August 1957), I wish to start a local teacher on his life membership in NSTA. He was an intern teacher for me a year ago and has since been

teaching in a Tallahassee high school. I discussed NSTA with him and offered to pay his first installment on a life membership as a little reward for his excellent work in developing the first regional science fair in northwest Florida. He agreed to this arrangement and I am enclosing a check for the first payment.

ROY N. JERVIS
East Texas State College
Commerce, Texas

I appreciate the packet service very much; it is the most treasured brown envelope I get during the teaching term. It certainly is a credit to those responsible for the cooperative efforts that produce it, and I am convinced there is much more vitalized teaching done across the nation because of it.

SISTER JANE FRANCES
Presentation Junior College
Aberdeen, South Dakota

The value of a program like STAR has become apparent to me in the past few months. As the result of publication of my 1956-57 medallion-winning entry, "The Activity of Germinating Pollen and Its Use in the Biology Classroom," in the special booklet, *STAR Ideas in Science Teaching* (see page 347 of this issue of *TST*), I have received numerous letters from teachers requesting information on the subject of my paper.

More important yet, I have received three letters and have even had a visit from high school pupils other than from my own school, who are using germinating pollen grains as term projects. I think these things prove that the STAR program is getting results.

ROBERT H. STRAHLENDORF
Biology Teacher
Mastbaum Vocational-Technical School
Philadelphia, Pennsylvania

How glad I was to see the article by Dr. I. Bernard Cohen printed in *The Science Teacher* ("The Impact of Science on Society," September 1957). I heard him present the talk on which the article was based at the NSTA convention in Cleveland (March 1957) and found it extremely inspirational. I felt that his speech accounted for a real "boost" to my subsequent teaching. I am very happy that other teachers who did not have the opportunity of hearing him may now read some of his remarks.

MRS. VERRELLE REID
Ashley, Ohio

Commenting on the magazine, I must say, with all sincerity, that I think it has improved in quality over the years and I feel that it fulfills its purposes, at least as I see them, admirably. I like the balance given to the various topics of science teaching and, for the most part, the articles are very well done. Occasionally I think that a particular writer could make better use of illustrations. I believe that photographs and drawings should be used wherever possible, even though they are not "professionally" done. Neatness is the important thing.

. . . Sometimes I think that the book reviews are apt to be too long and that, if we tried, we could say all that needs to be said in fewer words. Perhaps some words of encouragement would bring forth more people willing to help with the reviews.

There can be no real doubt of the high quality of *TST*. Keep it up!

J. STANLEY MARSHALL
Science Department
State Teachers College
Cortland, New York

I want to compliment the Association on the excellent *Elementary School Science Bulletin* for May 1957. The material on the International Geophysical Year was well presented. . . . I am looking forward to the new, expanded *ESSB*.

SYLVIA VOPNI
College of Education
University of Washington, Seattle

THE PHYSICAL SCIENCE STUDY:

Building a New Structure

A study that portends possibly revolutionary advancements in the teaching of secondary school physics is now going on, headquartered at the Massachusetts Institute of Technology in Cambridge, Massachusetts. Because of its potential significance and the trail-blazing steps it has already marked off, *The Science Teacher* presents here a special four-article report on THE PHYSICAL SCIENCE STUDY. The articles, written by leaders in the study, enunciate its background, its objectives, and its accomplishments to date. As future developments warrant, they will be reported in *TST*.

From These Beginnings . . .

By ELBERT P. LITTLE
Executive Director
Physical Science Study Committee

SINCE THE EARLY YEARS of the 20th century, the natural sciences have undergone two distinct and consequential changes. First, the sciences themselves have grown enormously, both in technique and in depth. Next, science has become inextricably interwoven with our daily life. We exist farther from the soil, closer to the laboratory; even more, science has left an ineradicable mark on our modes of thought and our methods of choosing between alternative courses of action. Modern man, whether he is aware of it or not, lives out his life in constant association with the methods of scientific research and the consequences of scientific research.

For some time, scientists and educators have been aware that this altered state of affairs is inadequately represented in secondary education (and as a consequence, in higher education). The teaching of science in the secondary school has indeed changed, and changed substantially, in the half century, both in content and in technique. But on the whole, the changes have consisted in additions to the structure that existed 50 years ago, or in alterations to the existing structure. Lately there have been repeated intimations that this piecemeal reconstruction has long since failed in its purposes; that a new structure is now necessary; and that it must be designed from the ground up.

The problem is most clearly seen in the secondary school physics syllabus. Structurally it goes back to the early part of the century, and despite the adjustments of the past five decades it represents quite clearly the state out of which the science was even then beginning to pass.

The syllabus is built around Newtonian mechanics, which had ruled physics for more than two centuries. The universe, as the physicist then saw it, was a Newtonian universe. A diagram of the solar system constituted a most appropriate frontispiece for a textbook on physics, for the universe as a whole was the solar system in the large, just as atoms and molecules were the solar system in the small. Accordingly, the course began with statics, went on to kinematics and dynamics, and in the light of these disciplines undertook to explain, one after another, heat, light, and sound. Such an organization of the subject was beyond criticism; it had a logical unity and it reflected both the current state of knowledge and the general attitude of the physicists.

In the years that have passed, physics has thrust out wider roots and borne unimaginably richer fruits. Quantum theory and relativity were postulated and developed; wave mechanics came into being and recreated the physicist's basic outlook; attention shifted from the particle to the atom, then to the nucleus, and now to the subnucleus. Newtonian mechanics lost none of its significance, but its status was changed; it no longer represented the manner in which the physicist regarded his universe.

The growth of the science, impressive as it was, did not begin to match the concurrent growth of the technology that was based upon it. Except for weather and the passage of day and night, most of modern man's environment literally did not exist 50 or 60 years ago: the processing which creates his foods; the fibers that go into his clothes; the automobile and airplane that carry him from place to place; the urban employments that earn him his living; the shadow pictures and the dancing electrons that constitute his leisure time activities. Add, if you like, air conditioning and the electric light, and even weather and time are under some sort of control. All of these are born of science, and somehow the educated man should have some intimacy with them all, beyond the intimacy of daily use.

The physics syllabus could not possibly remain

isolated from all these changes. As the science developed, the new subject matter was interpolated or added, as seemed most suitable. Technology was crowded in where it seemed pertinent. Textbooks grew in size and consequently diminished in comprehensibility. Because Newtonian mechanics rapidly ceased to serve as a unifying concept, the subject compartmentalized: physics insensibly became several distinct and disconnected subjects—mechanics, optics, heat, sound, electricity, the atom, the nucleus—grouped into one, it seemed, primarily for pedagogic purposes.

Since none of these could be covered adequately in the time at the teacher's disposal, the temptation grew to shift the emphasis from the science—which in any case was not being taught—to the technology, thus answering at least to the superficial interests of the student and rendering the subject matter manageable. The student could then be given, at the least, some insight into the workings of an internal combustion engine, a refrigerator, a radio, and (more recently) a space ship.

Under circumstances such as these, the task of the science teacher has become increasingly onerous. More and more, he teaches a subject that he himself does not recognize as science. If the brighter student is momentarily challenged to look upon the wider aspects of science, the syllabus is too hurried and too episodic to enable him to grasp any phase of it. The growing complexity of the material is not reflected in the school laboratory where the student, living in the world of the electron and the atom, struggles with pulleys and theoretical mechanical advantages. It is a rare boy or girl whom even the most devoted teacher can stimulate, in the face of such uninspiring subject matter.

New teaching techniques have done little to resolve the *impasse*. Bound as they are to the syllabus, they can bring only minor relief to the science teacher; they cast light upon detail, but leave the teacher to cope unaided with the contradictions inherent in the choice and arrangement of the subject matter.

Meanwhile, as the syllabus has come to be steadily less representative of the subject matter, the need has become greater. Science has become increasingly relevant to the career that a high school student is likely to follow, and the environment in which he will follow it. In the 19th century, most high school students could safely "take" science and forget it; physics would impinge very little upon his daily life. In the 20th century, physics is likely to be an integral part of his life. A large, and constantly increasing, proportion of high school students go on to make careers of science and engineering. The rest, whether as business men, lawyers, civic leaders, or skilled laborers, can almost certainly expect to come into intimate contact with it. More remotely, an ever-increasing proportion of the taxes they pay goes to scientific and engineering research or their fruits; the minimum demands of good citizenship require that there be some comprehension of what they mean.

But in the face of these realities, secondary school curricula fail to make science a meaningful part of general education. To that extent, general education lacks progressively any deep relevance to contemporary life, and fails to give adequate insight into how contemporary life is being shaped by science and technology. Misapprehensions about science in the public mind have become one of the principal reasons why we have today too few students studying for scientific careers, and too few teachers competent to teach science.

None of these considerations is the property of any one group. Since the war, dissatisfaction with the teaching of science in the secondary schools has been stimulated in many ways. Most powerfully, it has arisen out of the realization that our supply of scientists and engineers is not keeping pace with our bare needs, nor with the supply enjoyed by other great nations. Next, science teaching is failing in

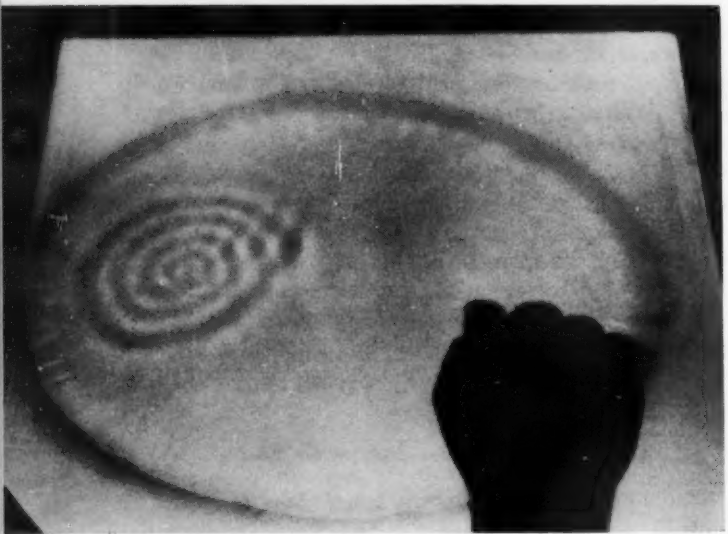
A bench-made telescope is characteristic of the "do-it-yourself" techniques of the course.

PHOKION KARAS

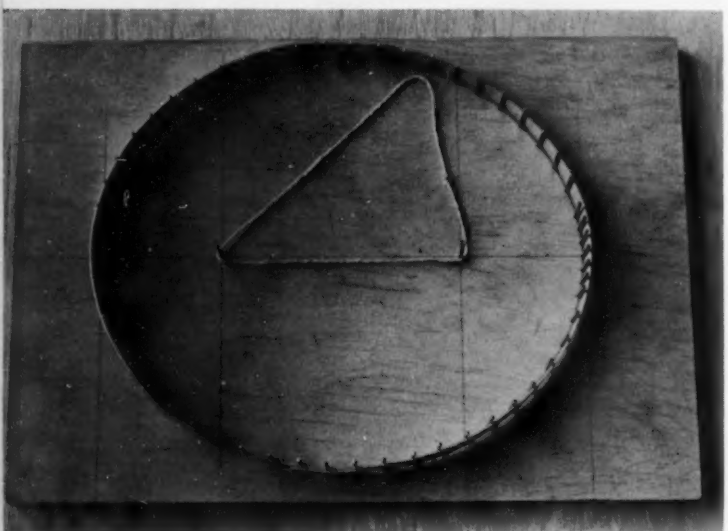
one of its most important functions: that of renewing in each generation an adequate supply of new teachers. In 1953 a Harvard University conference on Nationwide Problems of Science Teaching in the Secondary Schools reported that the supply of science teachers threatened to fall short of the demand by a full 50 per cent.

Finally, but not least in significance, there is a powerful intellectual discontent with the present status of science teaching: the scientist, the teacher, and the educated layman are all disturbed by the fact that it does not fairly represent science.

What is the view of science held by those persons who are aware of science and its meaning? The best description I know comes not from a scientist but from a philosopher—Charles Frankel of Columbia University. Science, says Professor Frankel in his eloquent book, ***The Case for Modern Man,*** "is an example par excellence of a liberal art—a deliberate, selective recording of experience, which releases men from the narrowness and urgency of routine affairs, carries them beyond the accidents and limitations of their lives, and makes it possible for their commerce with the world to have scope, order, and systematic consequences. It has been used as an instrument of . . . war, but its primary function is more humane and, as it were, aesthetic. And its relation to practice is the relation of any fine and liberating art—it carries men beyond the foreground of their experience, and enlarges the dimensions of human choice by acquainting men with the alternative possibilities of things. Quite apart from its technological applications, it represents, to use an old philosophical expression, a 'final good'—something which has its own inner dynamism, goes its own way, and can give stability and direction to the rest of our lives."

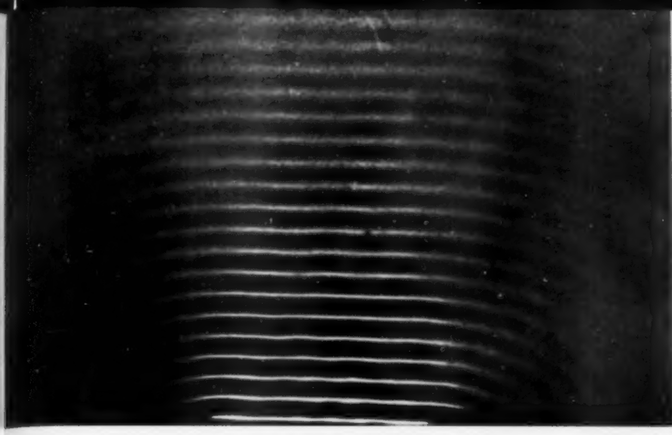


Water bounded by an ellipse shows wave reflection in a startling manner: a finger thrust into the water at one focus creates a wave "explosion" at the other.



Animated by an outlook such as this, the Physical Science Study Committee (PSSC) was organized in 1956, under a grant from the National Science Foundation, to seek ways of giving that outlook expression in the high school curriculum. Although the committee is administered by the Department of Sponsored Research of the Massachusetts Institute of Technology, it has at no time been exclusively an MIT project. From the outset it has been national in scope, enlisting its membership from universities and high schools across the continent. During the intensive summer program that has just been completed, more than 100 scientists, educators, and other contributors took part; of these, some 40 came from colleges, universities, and industrial laboratories; about the same number from secondary schools in all parts of the country; and the rest from the various communications industries—films, television, and the press.

The committee's work has so far fallen into two stages. During the first, which extended from its formation to the beginning of summer, the entire problem was studied—as much as possible *ab initio*. After considerable discussion, two far-reaching conclusions were agreed upon: to concentrate further consideration on the secondary school physics syllabus and to lay great emphasis on the development of new—perhaps radically new—teaching aids, without which it was felt no adequate program could be carried out. Thereafter, the physics syllabus was restudied and totally



A plane wave is diffracted passing through a slit in the ripple tank.

reformulated. The committee emerged from this stage with a clear conception of what it wished to accomplish, and of how it hoped to accomplish it. Professor Friedman's article in this issue of *The Science Teacher* summarizes both the conclusions and the manner in which they were reached.

The second stage, undertaken during the summer just past, was that of arriving at a first approximation of the teaching material that would embody this syllabus. A textbook has been written, and is now being published in four preliminary volumes. A program of 70 20-minute films has been embarked upon and will soon be in production. As Professor Zacharias reports elsewhere in this issue, appartus is being designed and constructed for classroom use, for laboratory use, and as a challenge to those students who might wish to strike off on their own in their kitchens or workshops. Under the supervision of Mrs. Laura Fermi, widow of the great Dr. Enrico Fermi, the first steps have been taken to provide low-cost, authoritative outside reading for the student who is stimulated to go beyond the text. Concurrently, the demands of the academic system itself are being met with the preparation of teacher's manuals, printed material to accompany laboratory apparatus and films, and examinations.

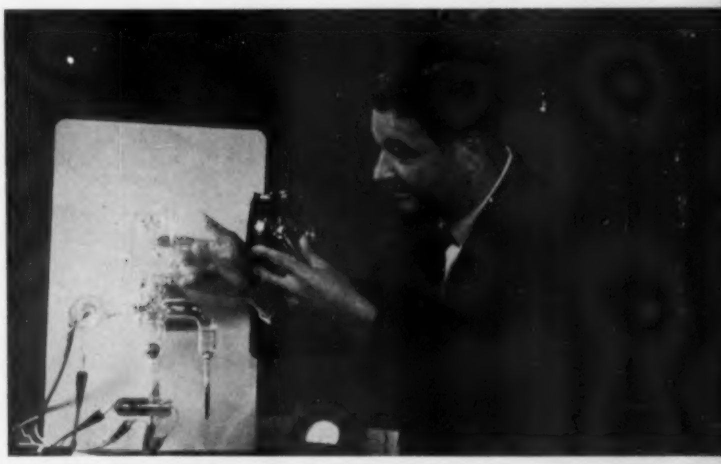
All this represents merely the first two stages in a program that will no doubt continue over the next four or five years. During the months ahead, the accomplishments of the committee will undergo the scrutiny of the teaching profession and the academic world, and the less formal scrutiny of the high school student. Classes will study from the text, which will no doubt reveal many strengths and weaknesses that the committee was not able to anticipate. Films will be made, and other aspects of the entire course will be pursued.

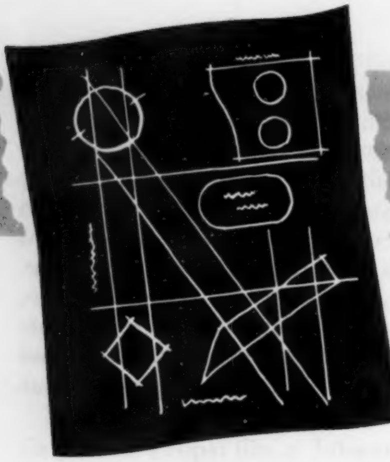
By the summer of 1958, it should be possible to embark on a second approximation of the text in the light of what has meanwhile been discovered. Films no doubt will be scrapped, and better ones produced. Summer institutes will embark upon the essential task of familiarizing science teachers with the details of what has been accomplished, and preparing them to take the course in hand. By the school year of 1958-1959, it should be possible to introduce the full course, together with a battery of completed teaching aids, into a number of representative secondary schools. Only then will a large-scale evaluation of the methods and the contents become possible. It will be on the basis of this final evaluation that the new physics syllabus will be put in determinate form.

If it is to be successful, it will require most of all the cooperation of the high school science teacher. He and his students are the customers for this product. The teacher must try it out, measure carefully its triumphs and its failures, and keep a constant feed-back flowing to the physicists, the educators, the editors, the film producers, the designers of apparatus, and all those who are seeking to put the course together. It will succeed in the schoolroom, and in the schoolroom alone; its form must in the end be determined by the schoolroom.

Those of us who are directly associated with the work entertain no doubts that it is an effort worth more labor and more devotion than anything else we do. Every teacher of science, by the nature of his profession, may feel himself equally associated with the task. Carrying it to a successful conclusion, we will all of us enrich not only our own lives, but the lives of millions of young men and young women in the generations that will follow us, and carry on our work.

A scene from the film on Light Pressure: Professor Zacharias demonstrates the effect of a high vacuum on a Crookes' Radiometer.





A Blueprint . . .

By FRANCIS L. FRIEDMAN
Associate Professor of Physics
Massachusetts Institute of Technology

WE ALL KNOW THAT SCIENCE is a human endeavor. The body of facts and theories which constitute our understanding of physical science is the result of a long development, a long and continuing effort by man to satisfy his curiosity and his needs. The history of discovery and invention in physical science is interwoven with all human history, and our picture of the physical world is one of the triumphs of thought. Both the present picture and the story of how we came to it and how we are now extending it are an essential part of our culture. We need some understanding of both the state and the process of physical science to live effectively in our world. The future lawyers, doctors, politicians, and "candlestick makers" should have an opportunity to learn how science evolves.

The general report of the Physical Science Study Committee includes the following statement of specific aims: "(1) To plan a course of study in which major developments of physics, up to the present time, are presented in a logical and integrated whole; (2) to present physics as an intellectual and cultural pursuit which is part of present-day human activity and achievement; and (3) to assist physics teachers, by means of various teaching aids, to carry out the proposed program." The course of study now being prepared by PSSC embodies these aspirations.

Almost without exception, the members of this committee would prefer to say "the physical sciences" wherever the word "physics" appears in the statement of aims; at minimum, they would like to combine physics and chemistry. But no reasonable account of both subjects can be presented in less than two years. As a consequence, the committee decided to concentrate its efforts primarily on physics, although chemistry is included where it fits naturally into the development of ideas. A similar revision of chemistry is left to another time (and the integrated, two-year course in physical science to that undetermined future when such a course will be practical).

Physics is usually an elective course, given in the 11th or 12th grade. As an initial goal the PSSC program is directed to the group of students now taking physics in secondary schools.

Finally, the committee is well aware that school science departments must run on budgets. The article by Professor Zacharias in this issue of *The Science Teacher* spells out in detail how the budgetary problem is being met in regard to laboratory equipment, where it is likely to be most acute. Other revisions to be proposed by PSSC will not involve secondary schools in unrealistic expense.

The PSSC course begins with a general introduction to the fundamental physical notions of time, space, and matter: how we grasp and how we measure them. As the student learns of the almost boundless range of dimension from the immensely large to the infinitesimally small, from microseconds to billions of years, he also finds out how these magnitudes can be measured and that instrumentation is simply an extension of his senses. We can thus teach measurement in order to answer real questions raised while we present the relative sizes of atoms, us, our world, the solar system, and the galaxy by more than mere assertion. This introduction anticipates qualitatively most of the rest of the course. The student should be led imperceptibly to realize that physics is a single subject of study—time, space, and matter cannot be separated—that it is a developing subject, and that this development does not take place outside our own intimate world. It is the imaginative work of men and women from whom the student does not noticeably differ.

From this introduction, the student should

emerge with a sense of the high adventure of physics and with some of the equipment he must have if he is to participate in that adventure, either through his career or as an intelligent citizen in a science-minded world. After looking at the broad picture, we start to examine it in more detail. Here we begin with light. There are many reasons for this choice rather than the more usual choice of mechanics. Light is a concept with which the student is immediately and convincingly familiar. He has seen rainbows, oil slicks, lenses, and the bent stick in the pond; he is prepared to accept light phenomena as something well within his ordinary experience. We live by light. The study of the manner in which light behaves can proceed by easy steps and can be supported by laboratory work that is at once simple and rigorous. It draws on the simplest of mathematics: simple geometric diagrams.

As it led historically, the natural development of the subject leads us first to explore certain laws such as Snell's law, and then to the development of a particle theory of light, which attempts to put an explanatory picture behind those laws. We distinguish broad physical theory from narrow physical law. Through careful investigation of light, the discussion illustrates the manner in which virtually all scientific knowledge develops. Under our continued scrutiny, the simple particle picture proves inadequate, and the student is led to concede that before we can proceed usefully with the study of light, we need to understand wave phenomena.

It is not a question of presenting waves as complex dynamical systems. The student observes the behavior of ropes and ripples. Studying this behavior, particularly under controlled conditions in the ripple tank, he learns to recognize a group of characteristics that constitute wave behavior. We then find these same characteristics in the behavior of light. Thus, at the end of this portion of the course, the earlier problems concerning the nature of light are resolved. At this point, as at others, we notice the new questions that inevitably arise from what we learn: what is the medium for light that acts like water for ripples? We raise such problems to show the open-ended nature of physical thought.

During this portion of the course, which occupies approximately the first half year, dynamical considerations are subordinated. At most, dynamics is treated descriptively. The principal emphasis is on the kinematics of our world: where things are, how big, and how they move, not why. The second half of the course now embarks on a study of dynamics. Newton's laws connect motions with forces. Not only can they be used to predict motions when forces are known, but they can inform us about forces when motions are observed. Thus we tell the extraordinary story of the discovery of universal gravitation. We also introduce the conservation laws, and they form a substantial portion of this section of the course. We stress their wide applicability and their use in situations where detail is inaccessible, such as cosmic ray collisions and the kinetic theory of gases.

Again in this part of the course, we go over ground viewed earlier, and the student will discover that he can read new significance into familiar material. Once again he will be impressed with the cyclical nature of the study of physics and with the constant refining process to which we subject physical knowledge. In the introductory section of the whole course, and again in the kinetic theory, we deal with submicroscopic particles. We now treat electricity as one of the fundamental characteristics of these particles. Currents, moving charges, and magnets are studied. Through the induction laws we arrive at the possibility of electromagnetic waves

A standing-wave model, made of drinking straws and thread, is demonstrated by Darrel Tomer of the Hanford (California) High School.

PHOKION KARAS

—a subject we can only sketch. The experimental facts, however, clearly tie the electric phenomena to the electromagnetic spectrum. Another great circle is closed, binding dynamics, electricity, optics, and waves in a single embracing picture.

The apparent completeness of this picture is denied by the photoelectric effect, but a more complete picture emerges before the end of the course. Through the discrete interactions of light with matter, we see photons; and through the photons and the experiments of Franck and Hertz on excitation, we see energy states in atoms. Our job is to describe both the wave patterns and the individual events that resemble the action of particles. This is nature and not, as is often said, a "contradiction." Instead of fighting straw men, we put the emphasis on describing nature. As de Broglie pointed out, the existence of wave-like and particle-like aspects of light suggest that there may be wave-like aspects of the behavior of matter. We can now show the wave nature through the same wave properties we found many times in our earlier wave discussion. The standing matter waves finally give the explanation of the energy states.

Let us look back for a moment and see how the wave concept, for example, pervades the course, and is used to deepen the student's understanding of science. In the introduction to the course, the identifying colors of characteristic spectra are used simply as evidence of the existence of elements and atoms. Next, in the study of waves, we identify spectral color with frequency. Then in mechanics and electricity, when we lay the basis of the Rutherford model, the introduction of photons changes frequency to energy. This permits us to associate spectra with the atom as a picture of its energy states; and the Bohr model results. Matter waves then finish the picture. The concepts of energy states and wave phenomena then carry us into the new realm of nuclear physics, where we are also able to examine the outstanding evidence that $E = mc^2$, and to understand the basis of nuclear fission and fusion.

A bench-made range finder.

PHOKION KARAS

In this course the logical unity of the subject is apparent. This integration of knowledge makes it possible for understanding to aid memory far more than usual. In addition, the integration of ideas gives the student the sense of a continuing development which in itself is intellectually exciting. The repeated appearance of certain concepts, such as submicroscopic particles, is essential. So also is the patient and detailed treatment of certain subjects. We explore parts of optics, mechanics, and atomic physics more deeply than usual in order to show how we develop a field of thought. The price is subordination and even omission of many subjects commonly covered in high school courses. Heat and sound are not treated as independent subjects, but more nearly as examples: sound as an example of waves, heat as related to kinetic theory and to the conservation of energy. Hydrostatics and hydrodynamics are out. Technological applications are cut far back at all points.

Such radical omissions are necessary. In fact, the committee's deliberations began with pleas from science teachers to reduce substantially the sheer bulk of the current physics course in order to fulfill its purposes within the time allotted to the subject. The material that remains in our selection still leaves a one-year course more crowded than the teacher would like. In the next phase of our work, we may learn where to cut still further.

Learning where to cut and where to build up is not the only job that remains for the next phase. The course outlined above reflects the emphasis and objectives of the committee, but it does not pretend to be "the answer" to good teaching of physical science. We hope to build it into an answer. How we hope to continue building is part of the subject of Professor Finlay's accompanying article. Where we are now, however, is not fully explained by the summary of our present ideas on course content. We have also tried to see how these ideas may be efficiently embodied.

To get the material across, we believe the resources of classroom, laboratory, and textbook must all be utilized. Work has already been going on to examine how each medium of teaching can

contribute. To put the material down and to look at it critically, we have written a preliminary text. This text was developed simultaneously with laboratory experiments; and although the text should be able to stand as nearly as possible on its own, it is written with laboratory work in mind. For example, teaching about waves by words alone is ridiculous. More information about the laboratory work is found in Professor Zacharias's article.

Often there are alternative ways of approaching a subject, and the questions raised by the study of a particular subject can be partially foreseen. To help teachers decide how they wish to discuss a subject and to prepare for the questions, we have collected the thoughts of teachers and authors in the beginnings of a teachers' resource book that we hope will grow and take more definite shape over the coming year. At the same time the present laboratory and text materials will be being used to start us on the improvements which will inevitably be needed.

Eventually we wish to make the visual representation of the subject more vivid by the use of motion pictures and filmstrips. Exploratory films have already been made and a large amount of work will be devoted to producing appropriate films in the coming year. They should relieve the teacher of some of the burden of demonstration by showing the unavailable and the expensive in the context of course. They cannot replace him or rob him of time necessary for discussion.

In addition to those often-covered topics that we believe have to be omitted, there is a wide stretch of other fascinating topics, many of which are within the grasp of interested high school students and which should be available although they are not part of any formal course. With this need in mind, the committee has started to prepare an extensive library of "monographs" dealing with material omitted from the course, with related fields like biophysics, with technology, the history of physics, and the lives of noted physicists. These monographs will be written specially for high school students. They will be available to the teacher who wishes to teach more, and to the student who wishes to learn more. Taken in their entirety, it is hoped these monographs will constitute an authoritative, readable library of science, available to the school or the student at a modest price. The committee has been fortunate in attracting a first-rate editorial board to see that the monographs are both readable and accurate. They have already signed up a number of excellent authors.

So far about a hundred people, mostly teachers of physical science, have contributed greatly to the work of PSSC. Far more have been of occasional help. To succeed in our aim will require much more work, but we recognize that we can make a real advance in teaching physical science.

PHOKION KARAS

Wave motion is demonstrated on the "slinky" by Mr. Tomer to David Woodbury of Educational TV Station WGBH in Boston.

The ripple tank being put into operation.

PHOKION KARAS

Into the Laboratory . . .

By JERROLD R. ZACHARIAS
Professor of Physics
Massachusetts Institute of Technology

IN DEVISING A NEW PHYSICS syllabus for the secondary school, the Physical Science Study group responsible for laboratory and demonstration apparatus shares all the problems of the textbook and film groups, and can offer several additional problems of its own.

The apparatus, of course, must be closely coordinated with the text, and the textual revision that is taking place must be accompanied by a thorough-going laboratory revision. As preceding articles in this report have made clear, the new course will rely considerably on wave motion. Much of the first half year will be devoted to waves, and much of the second half year will depend upon the student's ability to handle the concepts of wave motion and wave behavior. If this is to be accomplished effectively, the student must not only read about waves and watch waves; he must himself put waves through their paces. Only so much physics can come through the eyes and ears; the rest must pass through the hands.

These considerations apply equally to the fundamental particles, the second area of physics that the course will stress. Here, too, the apparatus group is exerting a major effort. For both waves and fundamental particles, laboratory material must start almost from scratch, for these are exactly the areas with which existing laboratory material is least prepared to cope.

The problem would be difficult enough if it encompassed only the content of the course. But, beyond this, the matter of cost must be kept constantly uppermost in mind. Laboratory equipment constitutes a major expense for a secondary school, and a course such as this, dealing with waves and particles in some of their most subtle and most delicate aspects, could easily pile up an equipment bill that would stagger the most generous school board. The work of the apparatus group was initiated with this fact firmly in mind. All costs have been measured in dimes and dollars; the expenditure of a ten dollar bill must be justified and rejustified before it is conceded; the higher denominations are spoken of only in jest.

Almost all the apparatus is designed to be built by the students themselves, either in the laboratory or (in rare instances) in the school's shop course. The building of apparatus is as much a part of physics as its judicious use, and the procedure is justifiable on these grounds alone. Beyond this, it makes it possible to provide extremely useful apparatus at prices that most teachers will find almost unbelievable.

The work of the apparatus group thus becomes a process of invention. It has been necessary to design entirely new experiments, using entirely new equipment. The equipment must be such that it is common to many experiments, and can be built from materials that are cheaply available. In practice, this last requirement has lead the group to seek materials that are in mass production for purposes other than pure science. An excellent example is the small six-volt motor, manufactured by the millions to power toys. These are excellent motors, and can be bought for a dollar or less. The apparatus group has already found a hundred uses for them, and finds more each day.

Finally, the conventional requirements of secondary school apparatus must be met: equipment must be easy to assemble, easy to disassemble, and must lend itself to economical storage.

The school laboratory for which all this is designed is expected to provide benches, 110-volt AC current outlets, and power supplies that will convert the current to provide up to ten amperes at six volts, or fractional amperage at 300 volts. In those experiments where greater voltages are called

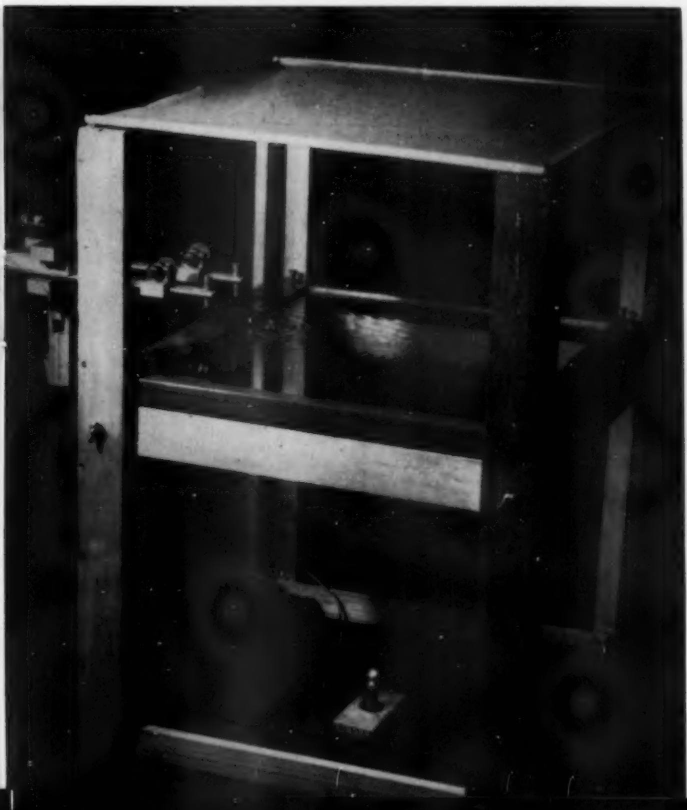
for they will be reached electrostatically, and amperages will be negligible.

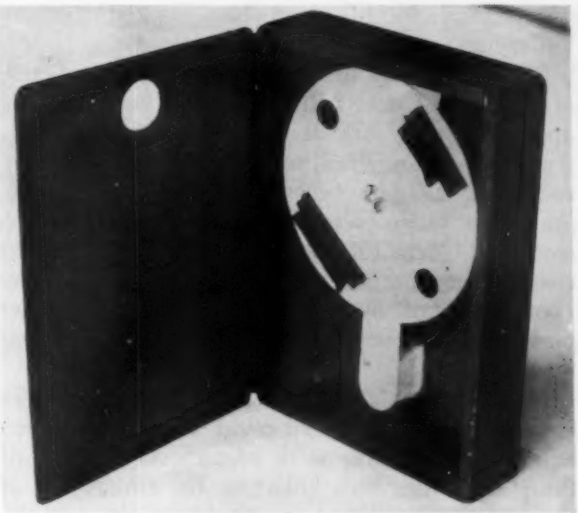
From this background, a new fact of immense significance emerges. The restrictions that the group has imposed upon itself have one immediate consequence: it is that almost all the equipment designed for the course can be built by the student for his personal use, at a cost that the average student can easily meet. There will be little the student will use in his school laboratory that he cannot duplicate in his garage or cellar. There he can modify, elaborate, or redesign an experiment, and set up "doing physics" on his own. For the ordinary student this fact is perhaps of little importance, but for the boy or girl whose nature it is to respond actively to the material in the course, it opens up endless horizons of excitement and adventure.

Pertinent here are descriptions of some of the equipment that has already been designed and built. The most important of these to date is the ripple tank.

This device will be central to the first part of the course. Waves can best be understood by the high school student if they are somehow materialized. Waves on ropes and waves on ponds constitute an admirable beginning, but almost immediately it is desirable to submit such waves to carefully controlled observation. For this purpose a ripple tank is admirably suited. Unfortunately, ripple tanks are ordinarily priced at $100 or more.

The ripple tank ready for operation with two point sources.





A working stroboscope, which can be built in class (or out) at a cost of less than a dollar.

The tank devised by the group is made of an ordinary window frame into which a pane of window glass is set. It is mounted on a wooden framework or on cinder blocks. Under the window pane, a 100-watt bulb is set and over it a sheet of paper is stretched; ripples on the surface of the water thus appear as shadows on the paper. The water surface itself can readily be two feet square or larger.

The driving mechanisms, for either plane or spherical waves, are made of wood, wire coat-hangers, and ping-pong balls, and powered by the six-volt motors. Altogether, the most lavish expenditure that can possibly be made for the materials that go into the device will amount to six or seven dollars. Two or three students can assemble it for the first time in an hour or so, and reassemble it in minutes.

With this tank it is possible to demonstrate plane and spherical pulses and periodic waves, reflection, refraction, diffraction, and interference patterns; to measure wave lengths and frequencies; and to elucidate the principles behind lenses, telescopes, and spectroscopes.

The ripple tank differs from other equipment developed for the course primarily in that at six dollars it is more expensive than most. A stroboscope designed for quantitative work will cost less than a dollar, a Michelson interferometer a few dollars. A microbalance capable of weighing a fly's wing is designed to be built of a drinking straw and needles, at a cost of pennies. Other devices being developed at costs of the same order

of magnitude include cloud chambers and titanium-ion vacuum tubes.

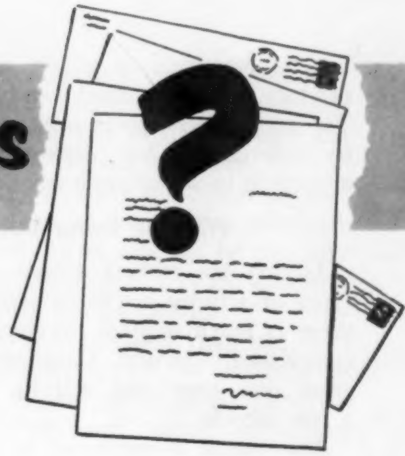
Similar work is being done on the construction of models for demonstration purposes. Like the apparatus, these are designed to be built by the students for the school, to be stored for reassembly each year as they become pertinent; these, too, are in the range of ten dollars or less. One such model will demonstrate the concept of molecular chaos, using marbles and revolving wooden vanes (powered again by the six-volt motor). Another model will demonstrate the processes of nuclear scattering.

The fact that all this is possible constitutes in itself a real discovery that could scarcely have been anticipated when the work began. As the field of the possible has been enlarged, the enthusiasm of the laboratory group has grown with it, and the program of the group now extends far beyond the range for which it was originally gathered. It is now clear that just as the textbook will be extended and amplified by monographs, the laboratory apparatus will be widely extended by the preparation of "do-it-yourself" experiments, ranging far beyond the material covered in the course. The student who is attracted by the monographs will have also available a whole series of experiments which he can build and work with, in school or out. They will be well within his grasp intellectually, mechanically, and—perhaps most important of all—financially. And they are not toys; they are real instruments of physical research, with which a bright student can retrace the work done by great scientists of the past, and perhaps take his first steps toward work of his own.

None of this, of course, is the work of a day or a month. The development of apparatus along these lines has only begun, and will continue for several years. During this period, it is hoped that the collective experience of the teaching profession will be steadily available to the PSSC apparatus group. The outcome, in which all science teachers will be able to share, will be a laboratory course that reveals something that people do with their hands and their minds—and something that is as enjoyable as it is worth-while.

Ripple tank with one of its two point sources in operation, producing simple waves in concentric circles. For a more complex pattern, produced from two point sources, see front cover of this issue.

What Are the Questions



By GILBERT FINLAY
Assistant to the Dean
College of Education, University of Illinois

The Physical Science Study Committee is engaged in a monumental task. It has attracted the effort of many men of varied talents. In its effort to present physics lucidly and vividly, it hopes to draw on the experience and imagination of many others. They are needed for, as PSSC is clearly aware, this is not a simple task of designing or redesigning physics curriculum. Trial-and-error testing is almost sure to produce, if not setbacks, at least unforeseen problems. PSSC must educate, too, as it carries on its work. Already teachers are asking questions. Some are plain requests for facts; others go deep into clashing principles of teaching.

For Whom Is the Program Intended?

As a beginning, the program is addressed to approximately the same secondary school group as now takes physics—about 25 per cent of the students who stay in school through the 12th year. It is not intended as an "advanced" secondary school course. What is recognized and hoped is that the program may prove to have broader applications.

The program is intended not only for the physics training of the future scientists but also for the general education in science of students looking ahead to nonscientific careers. Initially, the grade placement of the program is expected to fall normally in the junior or senior year of the secondary school. Whether it can be moved downward will be studied.

PSSC hopes that, in addition to finding application in schools now teaching physics, its program will make it possible to teach physics in some schools that, because of small size, have not been able to afford physics courses. The simplicity and relatively low cost of the PSSC equipment, together with the comprehensiveness of the teaching materials, are important in this regard.

Several teacher education institutions have expressed interest in the PSSC program in terms of its relationship to their work. These applications, perhaps others, will be studied when the committee is satisfied that it has approximated its initial goal.

What Is the Level of the Course?

How "hard" is the course? PSSC knows that, in some senses, its program will be regarded as a more difficult course than some standard courses. This the committee accepts. It would add that it expects its program to be stimulating. Improved exposition and illustration, a sense of getting nearer to the "bottom of things," pertinent demonstration, challenging experiment, and the availability of multiple resources should contribute to greater motivation on the part of students. They are also expected to contribute to greater satisfaction on the part of teachers.

The program will be regarded as radical by some. If so, this is not because the committee deliberately sought to be radical, but because it found that new approaches were needed to achieve the PSSC aims.

Because much of the content of text, demonstration, and experiment is novel, PSSC is approaching questions as to the level of difficulty with care. During the past summer and earlier, there has been much debate as to whether this subject or that exposition was appropriate for high school students. The procedural answer thus far has been to be careful not to underestimate what can be done with a challenging program. Within the limits of time and of working outside a school situation, physicists and teachers are putting materials in the best form possible. At the same time, they are being careful not to settle for too little. This has been done with the clear knowledge that some parts may be too difficult; some, perhaps, too elementary.

After the initial round of production, PSSC will

use its materials in a few schools to refine its product and move ahead to a better approximation. The committee expects to stay with its work until its materials are both consistent with its aims and adaptable to secondary school teaching.

What Is Being Done Now?

During the current school year, two principal types of activity are being carried forward. First, there is much original development yet to be accomplished. Second, those elements of the program now developed will be classroom-tested in a few schools.

The use of its materials in schools this year is not the result of any PSSC belief that the program is complete and ready for extended use. It is being done because the committee members recognize that evaluation of the materials in a teaching situation is a necessary step in their refinement.

The teachers using PSSC materials during the current year have assumed a significant responsibility. Because the materials are tentative, because they are—in some cases—marked departures from what has been conventionally taught, these teachers will be subject to unusual preparation requirements. Each of the teachers has worked through the past summer, and in some cases through last year, with the project. Each will teach throughout the year in close contact with physicists and other project personnel. The purpose of this is to help the teacher both prepare and evaluate what happens in his classroom.

Through visitation, conference, recordings, and reports, the classroom results will be closely studied. This will lead to the revision of existing materials and to the further definition of materials to be developed. Especially from these classrooms will come information leading to the further development of the teacher's manual and many guides for institute programs of teacher education.

How Will the Project Materials Be Disseminated?

By the beginning of the 1958-59 school year, PSSC expects to have advanced its program to a degree of completeness and quality that will permit limited tests of the over-all program and limited distribution of its materials.

The breadth and elements of newness of the program will, initially, make unusual demands upon teachers who wish to use the materials. During the summer of 1958, the committee anticipates that there will be a small number of summer institutes for teachers interested in becoming acquainted with the objectives of PSSC and using the materials on a trial basis. The location and program of these institutes will be announced as part of the regular Summer Institute program of the National Science Foundation, probably in December 1957. For the following years, plans are being considered for year-long institutes for more intensive supplementary preparation of teachers. PSSC hopes to arrange for demonstration classes in connection with the institutes.

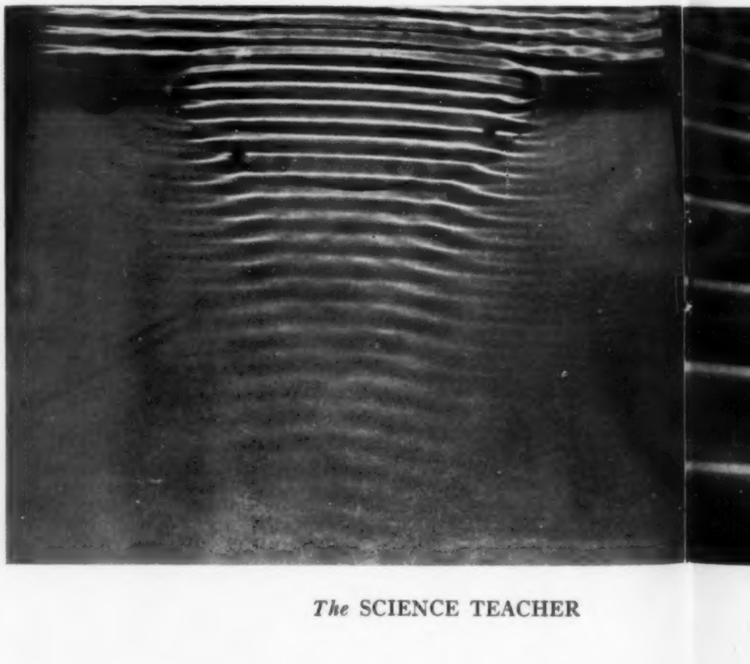
Where Does Mathematics Fit?

In the development of a new, comprehensive educational program, a number of related problems and considerations invite attention. For example, in PSSC, where does mathematics fit?

Considerable study is required of the relationship of mathematics to the teaching of secondary school physics. Initially, it is assumed that the physics student typically will have had two years of high school mathematics but that much of the mathematics required may need to be reviewed or taught. Certainly, mathematical ideas peculiar to the thinking of the physicists will be included. For example, where a rich intuitive rate of change is sought, it will be taught directly. In its future work, PSSC will be seeking a better definition of the optimum mathematics background for secondary school physics.

In relation to other courses in the curriculum, the PSSC monograph series will, PSSC believes, be a literary as well as physics resource. The mono-

A lens in a ripple tank: a curved glass surface reduces the depth of the water and focuses the water-waves that pass over it.



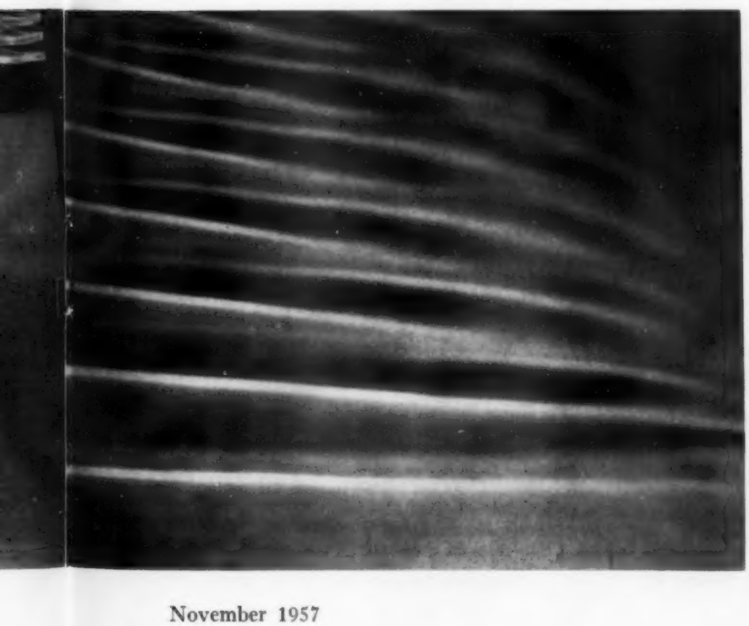
graphs will provide history, biography, philosophy, and exposition which should be of auxiliary importance to teachers of English. The committee hopes to get physics teachers and English teachers to consider jointly the kinds of English activities which would make sense to both.

What Are the College Relationship Problems?

This is a question which the committee has frankly faced. Certain general steps have been taken. PSSC is considering the relationship of its developing program to colleges and universities. It is taking steps to acquaint appropriate college and university personnel with the program. With college and university admission officers, PSSC is considering what, if any, supplemental information may be needed for students who study physics under the new program.

This is, however, a far more penetrating question. It is recognized that many professors of college freshman physics may tend to be more conservative in their attitude toward the PSSC-proposed course than their high school counterparts. It is PSSC's challenge to alert these professors to the purposes and nature of the course in such a way that it will gain both a sympathetic understanding and real enthusiasm for what it is, what it seeks to achieve, and its potential contribution to providing the most effective science teaching.

Refraction in the ripple tank: the tank is progressively shallower from left to right, and plane waves are therefore curved toward the shallower portion, where the wave travels more slowly.



One avenue of communication on which headway is being made is worth noting. This is channeling of knowledge about the study through the American Association of Physics Teachers.

A key to the progress of PSSC must lie in evaluation. It is essential that, as the program develops, both its strengths and its weaknesses be carefully assessed. In this, the committee has the cooperation of the Educational Testing Service, of Princeton, New Jersey. It is anticipated that end tests or achievement examinations will be designed to evaluate the results of the course as compared to the present so-called "standard" high school physics course.

PSSC frankly admits that its proposed course may leave large gaps in physics students' learning *when* viewed in the light of the current standard course. The question the committee seeks to answer is: Will the new course give insight, understanding, and the ability to use ideas to its students, as it aims to? Will it—and this is part of the same question—substitute the desire to *think things through* for the rote memorization that the standard course too often teaches?

An important phase of the college relationship question is: What happens to the PSSC-course student who must take college entrance examinations? There is no easy answer to this. The PSSC program aims to make knowledgeable science students. College entrance examinations are a measure of the same. One thing is clear in the minds of the committee members. There is no intent on the part of any of them, or anyone associated with the study, to attempt to hammer the proposed course into the school curriculum through the use of college entrance examinations. That is a truth in all phases of PSSC's relationships with teachers and the teaching of science, at any level. If the PSSC-proposed course is to achieve its objectives, it can only be done if the schools adopt it on its own merits and without any pressure leverage.

The questions and problems are here and will continue to arise. PSSC hopes to meet them and try to solve them as they develop. The committee has one end aim. It is to increase the perception and power of young people maturing in a culture in which science plays an increasingly important role. The final test of the program will be evident partially in the honest satisfaction of its many contributors. More important, it will be evident in the schoolrooms and laboratories, basement workshops, and youthful minds which can be examined by physicists, educators, fathers and mothers, and students themselves—who pronounce it good.

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SCOATS at Summit Lane

By MOLLY S. ALTER

Assistant Principal, Summit Lane Elementary School, Levittown, New York

SCOATS is a coined word with particular significance in the Long Island community of Levittown. It is derived from what is more formally called a *S*chool *C*ommunity *O*rganization to *A*ugment the *T*eaching of *S*cience.

SCOATS evolved from a plan worked out at the Summit Lane Elementary School in Levittown as a means of improving the teaching of science. The long-range goal was to help meet the nation's need for more scientists and science teachers. With the approval of the school's principal, Andrew M. Donnelly, the author developed the program in this way:

From names in the school's "resource" file, scientists—for the most part, parents of children in the school—were contacted and asked if they would be willing to help the staff toward a better understanding of science materials and equipment. Their response was highly gratifying, and in the summer of 1955 they met with Mr. Donnelly and myself to formulate plans.

This meeting was followed by a joint session of ten scientists and staff members of the school. The interest of the teachers was reflected by the attendance of more than 90 per cent of the staff although the meeting was entirely optional and was held during the summer vacation period.

At this second session each scientist was provided with a set of the basic science texts for grades 1 through 6, in order to become familiar with the curriculum. In addition, at this meeting, the curriculum was divided into the following broad areas:

1. Light and Sound
2. Electricity and Magnetism
3. Mechanics
4. The Universe
5. Weather
6. Life Sciences

Subcommittees were formed, each consisting of two scientists and several teachers, to study these broad areas of the science curriculum.

It was decided that an evening workshop would be prepared by each subcommittee for presentation to the entire staff. The subcommittees met seven or eight evenings in preparation for their workshop

Cartesian diver demonstration of air pressure absorbs staff members of the Summit Lane School at a SCOATS workshop.

This second grade activity unit followed a SCOATS weather workshop at the Summit Lane School.

Following a SCOATS workshop on mechanics, this third grade class is building simple machines out of milk containers.

A SCOATS scientist discusses meteorology in a fifth grade class at the Summit Lane School.

presentation and they constructed these workshops to include theory, demonstrations, and experiments. Ample time was provided for manipulation of the materials and equipment by the entire staff.

It was a most successful program and its effect on the science activities in the classroom was soon apparent. Teachers (particularly women) who previously had thought that handling a dry cell was comparable to being electrocuted were soon wiring up doll houses with lights and bells; during Halloween, pumpkins were lighted by bulbs instead of candles. Cans were heard collapsing in many rooms and "everyone was talking about the weather."

The traffic around the science equipment closet was heart-warming and microscopes, magnets, inclined planes, prisms, tuning forks, and the planetarium, to name just a few, no longer gathered dust.

In its second year the program continued with a slightly different orientation. The scientists assisted the administration in ordering science materials and equipment under the school's annual budget allotment. A two-point in-service training course, which met one evening a week, was conducted by the SCOATS scientists to familiarize the staff with the explanation and demonstration of the new science materials.

We are fortunate to have, among our parents, scientists from both industry and universities, in a broad variety of scientific fields. The group includes the following:

1. Physicist
2. Physical metallurgist
3. Meteorologist
4. Chemist
5. Botanist
6. Mechanical engineer
7. Electronic engineer
8. Astronomer
9. Expert in the field of rockets and guided missiles
10. Experimental psychologist

Several of the scientists are available, occasionally, to come into the classrooms to work directly with the children. With a natural curiosity about their environment, even at a very early age, children need no motivation. But their interests need to be encouraged and, above all, nurtured. A scientific attitude, observing phenomena, and performing simple experiments are within the scope of even kindergarten children.

The ability of five-year-olds to absorb scientific information was borne out by a discussion which one of the scientists carried on for almost an hour, on the subject of characteristics of species in a

A SCOATS workshop on the life sciences helped ease the typical aversion to mice on the part of distaff members of the faculty.

kindergarten class. The children amazed the school staff by their complete absorption and our notions of the attention span of five-year-olds were drastically altered.

The response of the parents and the community was most rewarding. The PTA purchased a weather station for the school. Classes will soon be predicting the weather. At present, they take readings, draw graphs, learn many new words, and, in general, continually correlate their science activities with mathematics and the language arts.

The SCOATS program has received a great deal of publicity both in local newspapers and in large metropolitan newspapers. As a result, requests for more information have come from Texas, Ohio, Virginia, Alabama, and Washington, D. C. The general pattern of the program could be followed in other communities with modifications to suit the specific needs and/or resources available.

A SCOATS scientist's discussion of the characteristic of species captures the interest of kindergarten pupils at Summit Lane School.

THE A AND Z OF S

WARNING—PROCEED WITH CAUTION

By ROBERT P. SHREVE

Science Coordinator, Austintown, Ohio, Public Schools and Director, Austintown-Fitch-TriCounty Science Fair

Few co-curricular activities have exceeded the phenomenal growth of the science fair in the United States in recent years. Such a great number of fairs have come into existence that virtually every school in the nation has access to a local, regional, or state fair. There can be little doubt that this movement has been a marvelous stimulus for developing interest and popularizing science. Project building seems to be one of the outstanding ways of providing a challenging situation for the gifted student and extending science beyond the classroom. These activities should continue to receive encouragement.

The quality of many exhibits and projects seen at these fairs is remarkable. Competition for awards and recognition has become so keen in some areas that an exhibit must be almost professional in nature before it receives notice. It appears, in some instances, that the desire for recognition has become so great that more attention is given to the presentation of the project than to the research and development of it.

Possibly it is time for a reappraisal of the values and purposes of science project building. Perhaps a premium is being placed on the product at the expense of the process. Perhaps skill in the industrial arts is becoming more important than the development of scientific understandings. This is not to imply that the development of skills is undesirable, but only that it is not the most important element in project building.

For a project to be of real value to its builder, a number of elements should be present, the most important of which is the knowledge and understanding of scientific principles achieved by the builder. What scientific value is there in building a project in which the builder merely follows instructions and actually learns little or nothing of the principles involved? Having recognized the importance of determining the extent to which this element is developed, some fairs have devised rules wherein it is necessary for the exhibitor to make an oral presentation of the project to the judges. This gives the judging team an opportunity to evaluate the knowledge gained and becomes a major factor in the rating of the project.

Sometimes questions pertaining to the project or the related field are asked by the judges as a means of further evaluation. Occasionally it has been evident that the presentations made by some exhibitors are, in fact, well-rehearsed speeches, possibly prepared by some well-wisher who wanted a particular protege to receive recognition. Questioning by the judges has revealed that little knowledge about either the project or the field is understood by the exhibitor. This type of practice is unfair to the other contestants, and it is cruelly unfair to the real victim, the person who built the project but did not learn the fundamentals. It is tragic, also, to think of the time wasted by this student. A smaller amount of time spent in study might have been more profitable for the student in the long run.

The real winner at a science fair is the participant who gave his problem a great deal of thought, developed some ability in research techniques, exhibited creative ability in developing a method of presentation, and developed some skill in actually building the project. Recognition may come to the scholar, but it is not his real aim.

Primary interest in showmanship and a desire to win at all costs could soon cause a degeneration of this entire program. Unless the objectives of a science fair are kept clearly in sight, science fairs may receive the same criticisms that have been leveled at interscholastic athletics in some areas, where winning has become more important than "character building."

SCIENCE FAIRS . . .

IN REBUTTAL

By DAVID KRAUS

Chairman, Science Department, Far Rockaway, New York, High School

THE description of techniques for producing science fair winners by Maitland P. Simmons in a recent issue[1] of *The Science Teacher* unfortunately presents several implications which might place student science competitions in an unfavorable light. It would seem that the author was so immersed in the thoroughgoing details of his theme that he neglected certain broader considerations of which he would normally be aware. As a result, excessive emphasis is placed upon the extrinsic achievement of winning, at the expense of recognizing the intrinsic value to students of the creative activities involved in a completed pupil entry. The comment of one parent was, "If my son possessed the qualities described by the author, I would encourage him to be a sales executive rather than a scientist."

The author's enthusiastic introductory statement is open to question: "More and more science teachers of our secondary schools are asking, 'How can we produce more science fair winners?' "

It is my belief, rather, that our teachers are asking, "How can we stimulate more and more of our pupils to engage in science projects so that they can gain experience in the methods of the scientist and develop enthusiasm in science as a career?" (The easiest way to produce more winners would be to give more prizes.) The winning of awards is an extra honor to the school which is doing a good job of instruction, but it is not the *ultima Thule;* nor is it the ultimate test of a school's program of enrichment for superior students.

When we examine the statements by teachers who have outstanding records for sponsoring award-winning students—and I think that we can consider these to be honest statements—we find little or no mention of prize winning as the goal of their project work. Rather, these teachers are trying to train citizens who have appropriate science knowledges, skills, attitudes, and appreciations, and they aim to guide qualified pupils into science as a career.

Consider, for example, the aims of Paul Kahn, now of the Bronx High School of Science (New York City), whose students won two cash awards and 31 honorable mentions in a single program of the Science Achievement Awards for Students. In describing[2] his procedures, he writes of a three-year sequence to "produce a steady stream of *creative science students*" and he tries to recognize and encourage pupils who "can *perceive a science problem or project*, original at least to him, and *carry it through* to a final conclusion." (Italics Mr. Kraus'.) Although he gives statistics on the number of awards his pupils won, the main emphasis is not on the winning of prizes but on the extent to which it is possible to unleash the scientific potentialities of youngsters.

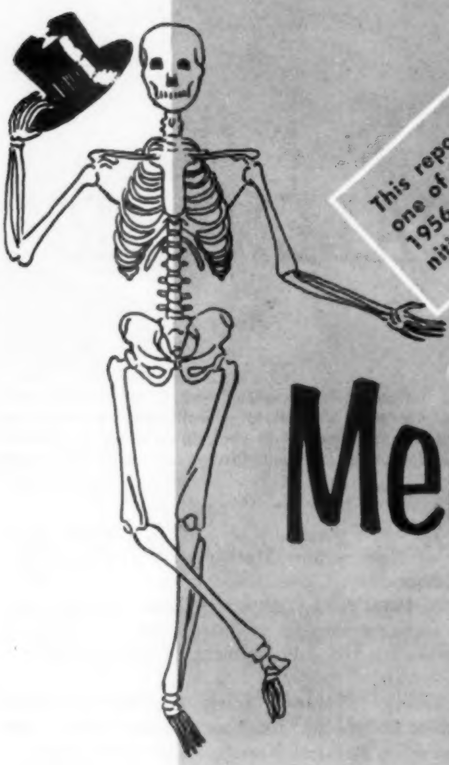
(Continued on page 356)

[1] Simmons, Maitland P.: "Let's Join the Science Fair Winners." *The Science Teacher*, 24:5, 225-227. Sept. 1957.

[2] Kahn, Paul: *STAR Ideas in Science Teaching*. National Science Teachers Association. 1957.

Maitland P. Simmons' article, "Let's Join the Science Fair Winners," in the September 1957 issue of *The Science Teacher* has evoked a number of favorable reactions, received both by the author and *TST*'s editors. However, there is obviously another "side to the coin," as has been evidenced by manuscripts submitted to *TST*. In the interests of objective reporting, two of these are printed here. Mr. Shreve's article was submitted for editorial consideration about the time Mr. Simmons' piece was on the press. Mr. Kraus' comments, on the other hand, were written as a rebuttal to Mr. Simmons' September article.

This report of a pupil project was one of the entries submitted in the 1956-1957 Science Teacher Recognition (STAR) awards program.



Meet Mr. Bones

By DANIEL BECKETT

Biology Instructor
Hempstead, New York, High School

LAST FALL I purchased a Halloween cardboard skeleton as a visual aid to assist me in teaching the skeletal system of the human body. At the time, I jokingly apologized for not having the real thing, little realizing that this remark would set off a chain of events that would keep me and five other students busy for some months to come.

The next day, Ted Creaser, one of my students, informed me that my Halloween skeleton could become a spectre of the past if I chose to accept an offer his father was willing to make me. Ted's father turned out to be Chairman of the Biology Department at nearby Hofstra College and he was prepared to offer me four crates of unassembled human bones, none of them complete. From this unique collection, one could, with some perseverance, conceivably sort out enough bones to construct a complete human skeleton ready for mounting. Originally these human bones came to Ted's father from a medical school which was retiring them from active service because they were incomplete for study purposes.

Needless to say, I accepted the offer and conceived the idea of a student project to assemble a complete skeleton. I had three principal goals in mind in connection with the project:

1. To supply our school with a skeleton as a permanent motivating visual aid in biology.
2. To contribute a difficult and challenging project for willing young biological minds to puzzle over.
3. To bring together a team of gifted biology students with a common goal.

It was indeed surprising and gratifying to discover how many students wished to participate in the project when I first introduced the idea to my classes. Eventually, I selected five students (three boys, two girls). My final selection was based upon such factors as:

1. The student's future interests such as medicine, dentistry, or engineering.
2. General aptitude and class interest in biology.
3. Willingness to persevere (purely a subjective decision on my part).

"E Pluribus Unum" might well have been the title of our initial endeavors because of the confusion of bones we had at our disposal. Of necessity, we divided into specialties by choice. For

example, two pupils tackled the task of assembling the bones in the hand. This alone was a formidable task—which is evident when one realizes that each hand and wrist is composed of 27 small bones. Naturally, a great deal of study and research had to precede the first attempt at assembly. Ultimately, these bones reluctantly yielded the shape of a human hand. All bones had to be drilled, wired, and glued in order to maintain their desired shape.

Other teams assembled ribs, feet, vertebrae, and long bones. The reconstruction of the 206 bones became at once a challenging engineering as well as biological puzzle. Every participating student quickly learned to distinguish between a carpal and a tarsal or a metacarpal and a metatarsal.

We worked after school at first until we deemed it more practical to move "Mr. Bones," as he was affectionately named by his creators, into the basement of my home in order to make use of Saturday mornings and holidays when school was closed.

One zealous student brought Mr. Bones' skull to her dentist where she was permitted to clean and polish the teeth after the dentist had cemented the loose teeth into the jaw. Never before did any skeleton's 28 teeth gleam with such a smile of beauty.

The local papers (*Newsday* and the *Long Island Daily Press*) heard about our project and gave the team some well-deserved publicity in the form of write-ups and pictures.

Mr. Bones will soon be moved into a newly ordered permanent glass display case in our biology laboratory—a fine tribute to those young biologists who have so capably demonstrated for all to see that skill, perseverance, and research are their own rewards.

NSTA CALENDAR

As a regular feature of *The Science Teacher*, the calendar will list meetings or events of interest to science teachers which are national or regional in scope. Send your dates to *TST*'s calendar editor. Space limitations prevent listings of state and local meetings.

November 29-30, 1957: Annual Convention, Central Association of Science and Mathematics Teachers, Chicago, Illinois

December 27-30, 1957: NSTA Annual Winter Meeting with science teaching societies affiliated with the American Association for the Advancement of Science, Indianapolis, Indiana

January 30-February 1, 1958: Annual Meeting, American Association of Physics Teachers in joint session with the American Physical Society, New York City

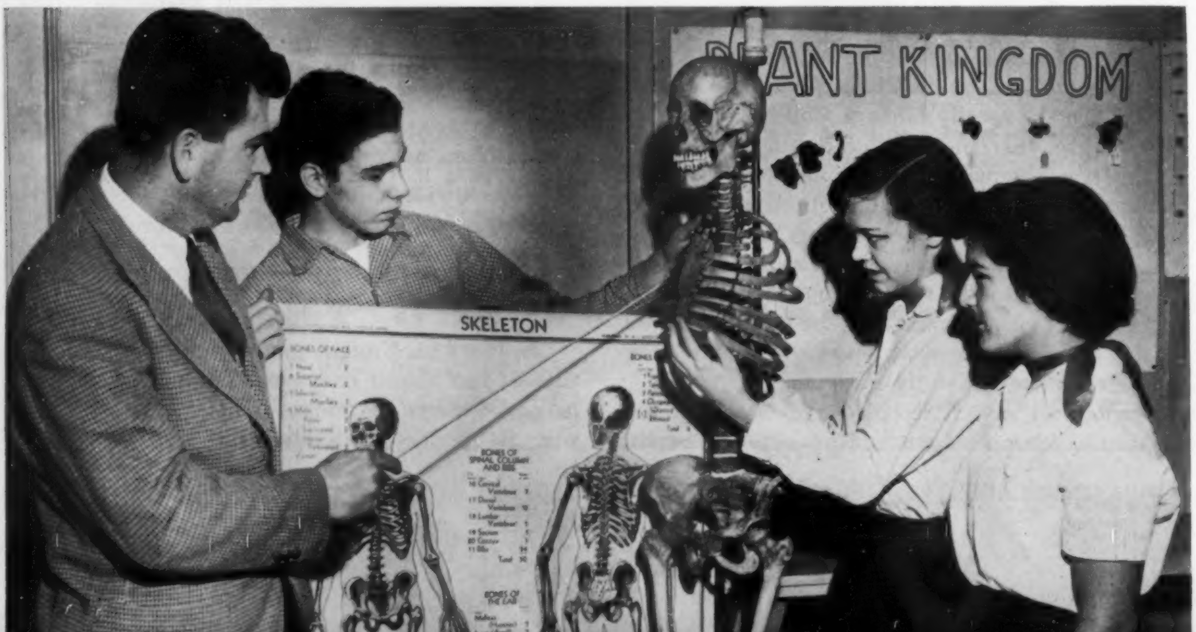
February 20-22, 1958: Annual Meeting, the National Association for Research in Science Teaching, Chicago, Illinois

March 26-29, 1958: NSTA Sixth National Convention, Denver, Colorado

April 24-25, 1958: 1958 Eastern States Health Education Conference, New York Academy of Medicine, New York City

June 25-26, 1958: NSTA Annual Summer Meeting with the National Education Association, The Ohio State University, Columbus

"Mr. Bones" commands the incomparable interest of realism as pupils study his composition and functions.



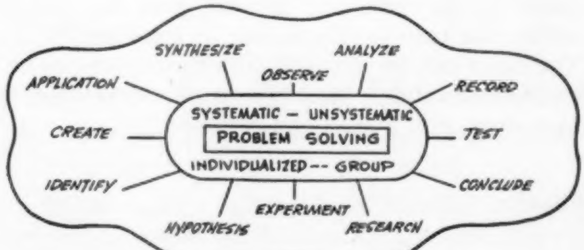
Problem Solving: A Changing Concept

By GEORGE C. TURNER

Biology Teacher, Claremont, California, High School

ONE OF OUR MOST PUBLICIZED OBJECTIVES in science education has come to be recognized and labelled as problem solving. Generally it is accepted as being efficient as well as productive thinking, but specifically it has run the gamut of semantic connotations. It has even been dismissed as nothing more than a synonym for *the* scientific method.

The confusion engendered by such comparisons has undoubtedly deterred many a science instructor from becoming too concerned with its inclusion in his lesson planning. My purpose here is to present a fast growing concept of problem solving along with an illustration of its use in a recent class of high school biology. The following diagram is a model in which the reader can identify elements intrinsic with most problematic procedures.



Some or all of the techniques shown in this diagram may be incorporated in a problem-solving situation. The amorphous structure is to connote that *no order* is necessarily followed when actively solving a problem. The mental gymnastics our thought processes go through likely bear little resemblance to the orderliness of a scientific method. This is not to say that a systematic treatment should be forgotten. On the contrary, an orderly arrangement of steps taken in solving a problem is most appropriate when one reports on it or even when one plans an attack on it. This might be visualized as a *superstructure* within which the building elements are known but their precise location is not. However, as the structure takes form, the architect can better select and manipulate the materials at hand for the most desirable finished product.

As helpful as a systematic approach may be in lending direction to the problem, the individual may unconsciously hop from analyzing a situation to concluding the results of his line of reasoning before he has even formed a recognizable hypothesis. This is believed by many students of problem solving as being a more realistic description of our thought processes. In fact, some propose that we have not probed deeply enough into the workings of the human mind to be able to fully identify the various mental manipulations involved. This approach is implicit in Harvard University's Advancement Management courses approach to problem solving. They commence with the admonition that no "principles" or procedures will be preached. Each student is to use his own methods to attack the various industrial problems presented.[1]

Dr. Joel Hildebrand[2] gave impetus to this concept of unpatterned thought in his Bamton Lectures delivered at Columbia University last year when he stated: "We proceed by common sense and ingenuity. There are no rules, only the principles of integrity and objectivity. . . ."

(Continued on page 350)

[1] Stryker, Perrin, "Can Executives be Taught to Think?" *Fortune Magazine*, 1953, XLVII, 138-188.

[2] Hildebrand, Joel H., *Science in the Making*, New York: Columbia University Press, 1957.

Classroom Ideas

Physics

A High Density Liquid for Floating Glass, Marble, and Quartz

By SANKARANARAYANA GIREESAN and ARCOT VISWANATHAN, Loyola College, Madras, India

Most often, mercury is used in demonstrations of the floating of high density materials. Here are directions for using a "water-like" liquid for this purpose.

Mix 65 g. of potassium iodide and 75 g. of mercuric iodide in a china dish and add precisely 15 ml. of pure water from a burette. Without applying heat, stir the mixture with a glass rod persistently until the red salt disappears completely. When the solution is filtered, about 30 ml. of a clear liquid of light amber color are obtained.

The solution is then equally divided among three tubes (6″ by 1″) into which balls of marble, blue-glass, and quartz crystal are dropped. These can be seen to float in the liquid. To prevent evaporation of the liquids, the tubes must be tightly corked or sealed.

The specific density of the solution of potassium mercuric-iodide (K_2HgI_4) as prepared above is 3.19 at 23° C. while the marble, glass, and quartz have densities of 2.6, 2.6, and 2.65, respectively.

The above was among the many science exhibits organized and sent by Professor L. M. Yeddanapalli, S.J., to the science fair held in connection with the centenary celebrations of the University of Madras in January 1957.

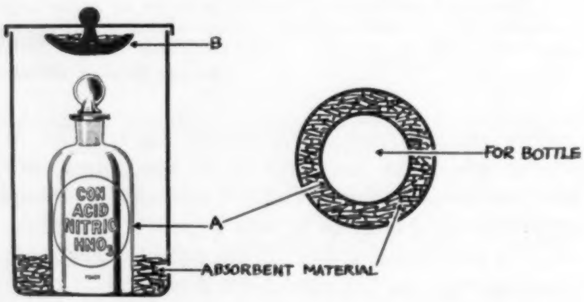
Chemistry

Storing Corrosive Reagents

By CARLOS M. P. WIRTH, Control Laboratory, The Sydney Ross Co., S.A., Mexico City, Mexico

In every laboratory, storing corrosive reagents in their ordinary containers is a constant problem. Contamination of adjacent reagent bottles, even the whole shelf nearby, oxidation of metal parts, etc., due to the fumes evolved, make such places dirty looking and create the need of cleaning them very often.

To cope with this problem, store such bottles in specially made polyethylene containers, which can be manufactured in various sizes according to the shape of the reagent bottle to be stored therein.



In the accompanying illustration, the polyethylene container (or any other suitable plastic material, transparent or opaque) is provided with an inner sealed-in ring-wall (a) of certain height. The absorbent material (calcium hydroxide, sodium bisulfate, calcuim chloride, etc.) is placed in the space between the container wall and the inner ring, whereas the reagent bottle is placed in the center. A similar trap (b) to be filled with the absorbent, can be molded in one piece with the cover of the container, so that even the fumes which may tend to escape may be absorbed easily. The cover can be provided with threads or can be made to slip tightly over the rim of the container, as is done with popular kitchenware.

Physics

Meeting a Challenge

By ROBERT MORRIS, Fort Dodge, Iowa, High School

During the early units in a conventional physics course, the bright students often go without challenge because many teachers proceed very slowly while trying to lay a sound foundation for the average student. The following is an attempt to alleviate this situation.

Make a number of wax alloys in this manner: Using paper cups as a mold, pour one inch of wax

into the bottom of the cup and allow it to harden. Add a varying number of rivets to each cup; record this number, and then pour another inch of wax on top of the rivets.

Allow this layer to solidify, then place a numbered piece of paper face side up to identify the alloy. Pour a thin layer of wax on this paper to keep it in place.

The alloy is now ready for use. The problem is to find the weight of the imbedded rivets. Every year one or two students work it out without any help, but the average student requires limited prompting.

The solution is based on the following:

(1) With two unknowns (mass of wax, mass of rivets), two equations are necessary.

(2) The mass is equal to the volume x density.

If x = vol. of rivets and
y = vol. of wax
these symbols may be inserted
into the two equations to the right:

$$\text{Total mass} = \text{mass}_1 + \text{mass}_2$$
$$\text{Total volume} = \text{vol.}_1 + \text{vol.}_2$$

By using x & y density to replace mass, solution is only a matter of a few mathematical steps.

I usually suggest that students attempting this make use of the scientific method and start by collecting as much information about the alloy as possible. I provide samples of the "pure" wax and rivets.

If necessary, after due length of time, I mention that it is possible to substitute V x D for mass. This usually provides the spark most students need to find the solution.

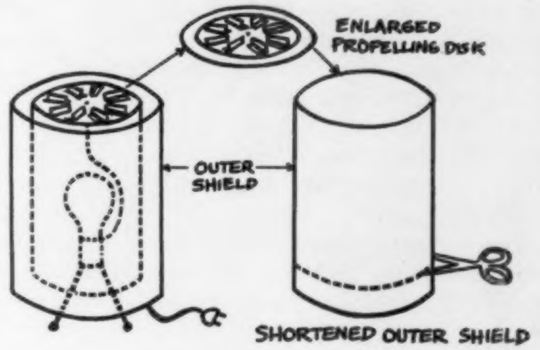
Biology

An Animated Mitosis Demonstration

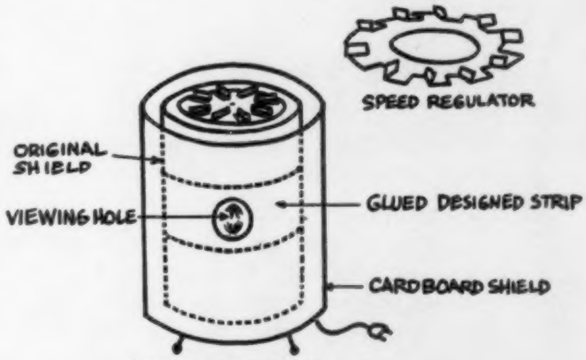
By RONALD O. KAPP, Botany Department, University of Michigan, Ann Arbor

While working as a graduate assistant in botany at the University of Michigan, I developed a device to show the steps of nuclei division, or mitosis, by modifying a rotating decorative lamp—the kind seen in many homes.

This particular lamp consists of a central incandescent bulb surrounded by two plastic cylinders. The inner cylinder is fitted with a metal disk containing slots and fins. As warm air from the hot bulb rises, the airstream is deflected by the fins, causing the plastic cylinder to rotate on the pointed metal pivot and jewel. As sold, the inner cylinder usually bears paintings of fish or butterflies which appear to swim past the design painted on the stationary outer cylinder.

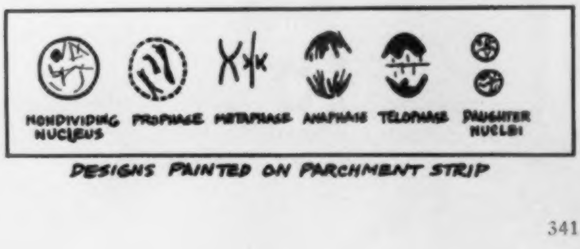


To prepare the mechanical device for demonstrating mitosis, the design on the *outer* cylinder was removed with an abrasive soap powder and the cylinder was shortened by about three inches. The propelling disk was then removed from the smaller cylinder and glued to a round piece of stiff cardboard with a hole large enough to allow air to pass through the slots. The outside dimensions allow



the propelling disk to fit snugly inside the top of the larger plastic cylinder.

A strip of parchment paper was cut to fit inside this larger cylinder and the stages of mitosis, represented by nuclei and three pairs of morphologically distinctive chromosomes, were painted in sequence on the paper with black enamel paint. The parchment was then fitted in the plastic cylinder and the lamp reassembled, with the smaller cylinder being discarded. The larger cylinder was



DESIGNS PAINTED ON PARCHMENT STRIP

used for the design because it provided a greater circumference.

A piece of plain posterboard was fitted around the entire lamp, after being shaped as a cylinder, and the mitotic stages were observed in sequence through a round hole in the cardboard shield.

Some difficulty was experienced in controlling the speed of rotation. A doughnut-shaped cardboard ring, with upward-projecting fins, was placed on top of the rotating cylinder, and slowed the rotation to the desired speed.

This animated demonstration made an effective teaching display in the hall cases of our botany department. Such a device could be used effectively in biology for demonstrating sequential events such as mitosis, meiosis, embryological development, and plant and animal life cycles. It could be used in high school as well as college biology teaching, both as a classroom aid and as a display demonstration. The total cost of the device was less than six dollars and the alterations and adjustments can be completed in the short time of two or three hours.

Physical Science

Teaching Aids for Nuclear Energy

By WAYNE H. KINCAID, Emmerich Manual Training High School, Indianapolis, Indiana

In trying to dramatize some of the facts about nuclear structure a common marble mounted as shown in Figure 1 is useful. This marble, if nuclear material, would weigh 400 billion pounds (4×10^{11}). This point can be emphasized also by choosing a member of the class who weighs about 200 pounds and indicating that, if he were compressed so that he was nothing but solid matter, he would be a speck just visible through a microscope. Since this speck has lost no weight, it would still weigh 200 pounds.

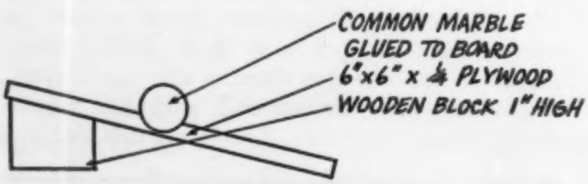


Figure 1. A common marble used to illustrate the weight of nuclear material.

A pin mounted on a board similar to the marble shown in Figure 1 can be used to point out the very small size of atoms. The pin head contains 100 billion billion atoms (10^{20}). If the nucleus of a hydrogen atom were enlarged to the size of the pin head, then the entire atom would be as high as a 30-story building. A bit of black paint applied to the pin head makes it more readily visible.

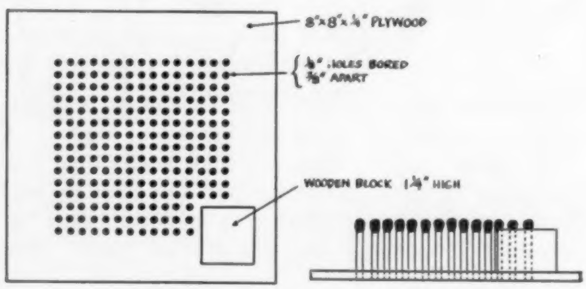
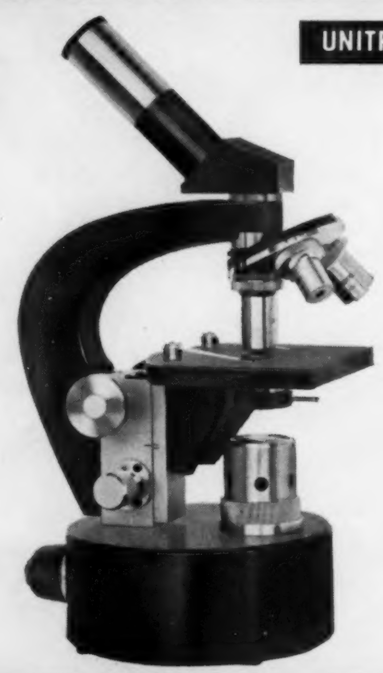


Figure 2. Matchboard for showing a chain reaction.

A touch of realism can be added to the discussion of a chain reaction leading to an atomic explosion by making a chain reaction matchboard. Bore ⅛-inch holes ⅜ of an inch apart in a piece of plywood about eight inches square, leaving a border around the edge. Place a small wooden block about 1¼ inches high at one corner. See Figure 2. Put matches in each of the holes. The heads represent U-235 nuclei. The chain reaction is started by the "fission of one nucleus" by igniting it with a lighted match. The reaction then spreads across the board from match head to match head. A final touch is given to the reaction by placing on a piece of paper on the wooden block a mixture of ¼ gram of powdered magnesium and ¾ gram of potassium chlorate. The flame ignites the mixture which results in an explosion and a mushroom cloud that is characteristic of an atomic blast. The flaming matches can be extinguished by covering them with the top of a cake pan or any available can of appropriate size.

UNITRON student microscopes offer

UNITRON STUDENT AUTO-ILLUMINATION MICROSCOPE, MSA



The UNITRON Student Auto-Illumination Microscope, Model MSA, employs a newly designed stand in which all components and controls are within easy reach. The inclined eyepiece tube allows comfortable posture and may be turned in any optional observing direction to permit two students sitting side by side to share a single instrument. With the built-in illuminating system of the superior low-voltage type, each student is assured of the correct lighting. The transformer is conveniently housed in the microscope base itself where it contributes to the stability of the stand rather than to the clutter of the laboratory table.

Model MSA comes complete with triple revolving nosepiece and three objectives: 4X, 10X, 40X; three eyepieces: 5X, 10X, 15X; coarse focusing with safety stop; fine focusing; condenser and iris diaphragm; filter holder and filter; accessory substage mirror; wooden cabinet and dustcover. Mechanical stage available at extra cost.

only $107

UNITRON STUDENT MICROSCOPE, MUS

Despite its low cost, UNITRON Model MUS offers features lacking even in much more costly models usually offered for student use. For example, both fine and coarse focusing are provided — not merely a single focusing control; an iris diaphragm to regulate aperture for highest resolution — not merely a disk diaphragm; and a condenser system for optimum illumination.

The optical performance of Model MUS at each of its magnifications is equivalent to that of expensive research models. All mechanical parts are machined to close tolerances and the stand is beautifully finished in black and chrome. Model MUS comes complete with triple revolving nosepiece and three objectives: 5X, 10X, 40X; choice of two eyepieces from: 5X, 10X, 15X; coarse focusing (accessory safety stop available); condenser with iris diaphragm; inclinable stand; planoconcave mirror; wooden cabinet and dustcover. Mechanical stage available at extra cost.

only $74

NSTA Activities

Indianapolis Meeting

December 27 through 29 are the dates of the NSTA annual winter meeting with science teaching societies affiliated with the American Association for the Advancement of Science. Indianapolis, Indiana is the place with the Hotel Antlers as headquarters. The groups taking part in the meeting with NSTA are the American Nature Study Society, the National Association for Research in Science Teaching, and the National Association of Biology Teachers.

A diversified program has been arranged for the meeting. The opening session Friday morning, December 27, will feature "Current Trends in the Science Curriculum, Grades 1-12," with John S. Richardson, of The Ohio State University, Columbus, retiring NSTA president, speaking. His talk will be followed by a symposium on "Strengthening Some Classroom Foundations." Friday afternoon's program calls for industrial field trips. A Saturday morning symposium will take up "Teaching the Major Concepts" with panels on Relativity, Evolution, and Individuality of Man. That afternoon there will be two separate sessions, one a "Here's How I Do It" meeting and the other a problem clinic on "Grass Root Problems in Elementary Science." NSTA president Glenn O. Blough will preside at the latter.

Among other featured participants will be NARST past president George Mallinson, NABT president John Breukelman, and ANSS president Richard Weaver, as well as distinguished university and secondary school science teachers and education administrators. The NSTA chairman for the meeting is Richard W. Schulz, of the physics department, Purdue University, Lafayette, Indiana.

Teachers planning to attend should request hotel reservations immediately; write for data to Dr. Raymond L. Taylor, American Association for the Advancement of Science, 1515 Massachusetts Avenue, N. W., Washington 5, D. C.

STAR Points

STAR's second year is off to a good start, launched by the success of a product of the 1956-57 Science Teacher Achievement Recognition awards program. This is the brochure, "STAR Ideas in Science Teaching," an attractively designed publication containing 13 of the cash and medallion award-winning entries in the first year's program. Orginally a limited number of copies were printed. However, science teachers and supervisors who either received or saw the brochure found its ideas so practical and helpful that there was a demand for a new printing.

The brochure is now available at NSTA headquarters (1201 Sixteenth Street, N. W., Washington 6, D. C.). Single copies are $1; quantity discounts are available. Covering various fields of science activities, the articles are grouped under three headings: Teaching Methods, Teaching Aids and Equipment, and Out-of-School Activities for Teachers and Pupils.

The new publication is also an updated replacement for NSTA's "Selected Science Teaching Ideas of 1952," which is now out of print.

Plans for STAR's second year include publication of a similar brochure next year, presenting a cross-section of reports from the winning entries. Conducted by NSTA under a grant from the U.S. National Cancer Institute, STAR '58 is an expanded program with cash awards of $6750 to be made to 50 teachers in place of the 1956-57 awards totaling $2000 to ten teachers. The deadline for the new program is February 15, 1958.

Details of STAR '58 were published in the October issue of *TST* (page 282). A special four-page flyer describing the program and including a coupon for the official entry form and special materials is also available. Science teachers who have not received this flyer should write to NSTA headquarters for it.

On the Colorado Trail

There is an almost-immediate deadline on an important phase of planning for the NSTA 6th National Convention in Denver. It relates to the Curbstone Clinics which proved so popular at the Cleveland convention last spring that they are being repeated at Denver.

A list of 25 tentative questions and topics for the clinics has been drawn up and leadership teams are now being developed for each. NSTA members and other *TST* readers who want to take part should write NSTA headquarters *at once,* volunteering their services and indicating in "1-2-3" order their topic preferences. Since convention program copy must be finalized soon after December 10, prompt action on this is imperative.

These are the 25 topics: (1) Teaching the academically able students in science in junior and senior high schools. (2) Science fairs in junior and senior high

schools. (3) Science fairs in the elementary school program. (4) Conservation—how, when, and where in the science program? (5) Health education—how, when, and where in the science program? (6) More effective use of textbooks and services provided by publishers. (7), (8), and (9) TV experiments in the teaching of science—elementary, secondary, and collegiate respectively. (10) Using business-sponsored aids in teaching science. (11) Improving the use of audio-visual aids in science. (12) Little field trips for little folks in elementary schools. (13) The field trip in secondary school science. (14) Summer institutes and conferences for high school teachers. (15) "On-the-job" research grants for secondary school science teachers. (16) The Physical Science Study—an experiment in the redesign of high school physics. (17) The science program in the small high school. (18) A science program for grades K-12: scope, sequence, planning, execution.

(19) Science teachers' opportunities and responsibilities in the "career day" movement. (20) Encouraging future scientists and science teachers—materials, programs, techniques. (21) Supervision of science teaching—what kind, how much, techniques, successful programs. (22) NSTA's Commission on Education in the Basic Sciences. (23) NSTA's Future Scientists of America Foundation. (24) Evaluation of learning in science—instruments, procedures, role of NSTA committees in this area. (25) Using current scientific discoveries in the teaching of science.

A comprehensive and varied list? The Denver convention committee did a painstaking job in developing it. Write about your preferences immediately. And also start planning now for your attendance at Denver. These are the dates: March 26 through 29, 1958.

You Can Depend on the GENATRON

● *The MODERN Electrostatic Generator*

THE CAMBOSCO GENATRON serves not only for classical experiments in static electricity, but also for new and dramatic demonstrations that are not performable by any other means. It exemplifies a modern method of building up the tremendous high voltages required for atomic fission, for nuclear research, and for radiation therapy.

Entirely self-exciting, the GENATRON cracks into action at the snap of the switch—whose only function is that of starting the motor drive. No auxiliary charging method is employed. Hence, despite an output measured in hundreds of thousands of volts, no hazard is involved, for the operator or for the observers.

GENATRON, WITH MOTOR DRIVE
Operates on 110-volt A.C. or 110-volt D.C.
Includes: Discharge Terminal, Lucite Insulating Cylinder, Latex Charge-Carrying Belt, Discharge Ball with Flexible Shaft, Accessory and Ground Jacks, Cast Metal Base with built-in Motor Drive, Connecting Cord, Plug. Switch, and Operating Instructions.
No. 61-705 .... $98.75

An Output of 250,000 Volts—or More!

THE CAMBOSCO GENATRON is designed to deliver, in normal operation, a discharge of the order of 250,000 volts. That figure, a conservative rating, is based on many trials conducted under average conditions. With ideal conditions, a potential difference of 400,000 volts has been achieved.

Modern Design— Sturdy construction and ever-dependable performance distinguish the GENATRON from all electrostatic devices hitherto available for demonstration work in Physics. This powerful, high-potential source, reflecting the benefits of extensive experience in electrostatic engineering, has absolutely nothing but purpose in common with the old fashioned static machine!

NO FRAGILE PARTS—Durability was a prime consideration in the design of the GENATRON which, with the exception of insulating members, is constructed entirely of metal.

The only part subject to deterioration is the charge-carrying belt, which is readily replaceable.

NO TRANSFER BODIES—In all conventional influence machines, whether of Holtz or Wimshurst type, electrical charges are collected and conveyed (from rotating plates to electrodes) by a system of "transfer bodies." Such bodies have always taken the form of metal brushes, rods, button disks or segments—each of which, inevitably, permits leakage of the very charge it is intended to carry, and thereby sharply limits the maximum output voltage.

It is a distinguishing difference of the GENATRON that electrical charges, conveyed by a non-metallic material, are established *directly upon the discharge terminal*. The attainable voltage accordingly depends only upon the geometry of that terminal and the dielectric strength of the medium by which it is surrounded.

Unique Features of the CamboscO Genatron

DISCHARGE TERMINAL Charges accumulate on, and discharge takes place from, the outer surface of a polished metal "sphere"—or, more accurately, an oblate spheroid.

The upper hemisphere is flattened at the pole to afford a horizontal support for such static accessories as must be insulated from ground. A built-in jack, at the center of that horizontal area, accepts a standard banana plug. Connections may thus be made to accessories located at a distance from the GENATRON.

CHARGE-CARRYING BELT To the terminal, charges are conveyed by an endless band of pure, live latex—a CamboscO development which has none of the shortcomings inherent in a belt with an overlap joint.

DISCHARGE BALL High voltage demonstrations often require a "spark gap" whose width can be varied without immobilizing either of the operator's hands.

That problem is ingeniously solved in the GENATRON, by mounting the discharge ball on a flexible shaft, which maintains any shape into which it is bent. Thus the discharge ball may be positioned at any desired distance (over a sixteen-inch range) from the discharge terminal.

BASE...AND DRIVING MECHANISM Stability is assured by the massive, cast metal base—where deep sockets are provided for the flexible shaft which carries the discharge ball, and for the lucite cylinder which supports, and insulates, the discharge terminal.

The flat, top surface of the base, (electrically speaking), represents the ground plane. Actual connection to ground is made through a conveniently located Jack-in-Head Binding Post. The base of the Genatron encloses, and electrically shields, the entire driving mechanism.

PRINCIPAL DIMENSIONS The overall height of the GENATRON is 31 in. Diameters of Discharge Ball and Terminal are, respectively, 3 in. and 10 in. The base measures 5¾ x 7 x 14 in.

GENATRON, WITH SPEED CONTROL
Includes (in addition to equipment itemized under No. 61-705) built-in Rheostat, for demonstrations requiring less than maximum output.
No. 61-708 .... $109.00

No. 61-710 Endless Belt. Of pure latex. For replacement in No. 61-705 or No. 61-708 . . $3.00

CAMBOSCO SCIENTIFIC COMPANY

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TURNER . . . from page 339

A slight variation of this theme was proposed in a symposium on problem solving published in *The Science Teacher.* Dr. Oreon Keeslar [3] there stated: ". . . in problem solving, let us anticipate the human element and welcome original methods for each problem situation, but hope that these incorporate such of the elements and scientific method as the situation warrants."

Thus, advocates of original, unpatterned thought in attacking problems have made themselves heard in the areas of business, science, and education. How then can such a disorderly combination of individualized techniques be taught?

As I see it, the answer would be that, like the unpatterned nature of the subject, they can not be taught as an organized unit. Instead, they must be handled individually both as pertaining to the student and to the elements of problem solving. In addition, a conscious effort to include one or more of them in all subject matter considerations is necessary to insure a desirable facility with them.

An illustration of a lesson with this objective in mind took place last year in a biology class when a study of insects was about to be launched. The instructor had prepared for the unit by encouraging some flies to ovulate on a few pieces of raw meat. After pupation had occurred, the plastic-like capsules of developing flies were given to the students. The distribution of the pupae was accompanied with instructions to find out all the information available on these "plastic" capsules and their soon-to-emerge occupants.

As you can imagine, interest was at a peak (and more than a few class activities disrupted during the day). But also, many careful, and not so careful, records were kept describing every action of the emerging fly until it took wing, often timed to the tenth of a second. The subsequent comparison of notes and explanations of events caused many students to ask for additional capsules to check findings or just to do a better job. As enthusiasm grew, so did requests for sources of information on these interesting little pests. Of course, little buzz groups got started in and out of class with copious suggestions cn different authoritative sources. These sources often conflicted on small but interesting points.

For example, the time taken for the fly to take wing after emerging from its pupa case brought on quite a heated discussion, which got no one any-

[3] Keeslar, Oreon, "The Science Teacher and Problem Solving," *The Science Teacher*, 1956, XXIII, 13-69.

where. Fortunately, we had an erstwhile "Galileo" in our class who suggested a possible experiment by which original observations could be made. Unlike Galileo's contemporaries, the class was soon engrossed in refinements and alterations of the original suggestion, until a generally acceptable experiment was devised—controls and all. The setup for our quest of observable facts was quite simple, but the thought processes involved in deriving it were somewhat complex.

Three groups of students undertook to do the experiment independently, both for the fun of doing it and "to make sure it was done right." It consisted of placing about-to-emerge pupae in three different temperature conditions, all other factors being kept constant. The temperature variations were developed by devising makeshift, camping-style coolers, light bulb-warmed heaters, and room temperature. The guess (hypothesis) was that the authoritative source in question had made his observations on warmer days and therefore got a shorter average time for the flies' final development. Our findings seemed to indicate that this was likely the case.

All was not smooth sailing. Rough spots appeared and instructor guidance was often necessary. However, considering the age and inexperience of the students, they progressed (and at times groped) to a generally acceptable conclusion. In fact, the experimental "bug" had bitten quite a few students and repeated requests for "proving" something or "finding out" things occurred throughout the year. Individual problems were often attached and solved before the instructor knew they were being contemplated—and just for the sake of knowing.

The instructor's role is seldom a small one in endeavors such as these. A familiarization with both the workings of the adolescent mind and many of the techniques used in solving problems are essential. These techniques, although not necessarily used in a particular situation, can be referred to if the students are unable to proceed by their own methods. A few helpful, but not authoritative, hints are often essential to keep the discussion moving at a rapid rate and in an interesting vein. It takes more than one attempt for this kind of teaching to become familiar territory for the instructor; but once the path is known, the obstacles are few. The diversity in individual student thought processes becomes an intriguing quantity seldom explored in "standard" type science courses.

FSA Activities

Action for 1957-58

For the sixth consecutive year, representatives of business-industry, high school science teaching, college and university science, and scientific societies have "put their heads together" for a specific purpose. This was to advise on services and action programs which NSTA's Future Scientists of America Foundation should provide to assist teachers in encouraging tomorrow's scientists. The occasion was FSAF's annual "open meeting," held October 4 in Washington, D. C. Here is a brief rundown of projects approved or recommended by the conference.

1. Booklets. Two new service booklets are planned for early publication. One of these will deal with "How Scientists, Engineers, and Industry Can Help Science Teachers and Their Students;" it is now in preparation by a committee headed by Dr. Warren Nelson of Miami University, Oxford, Ohio. The second booklet is being prepared by a committee under the chairmanship of Dr. Robert Donaldson of Plattsburgh, New York, State University Teachers College; it will deal with "How Science Teachers Can Work More Effectively With the Academically Able Students in Science."

2. Summer Opportunities for Teachers. FSAF has been advised to continue its efforts to catalyze summer employment opportunities in science-based industries. The same advice applies to opportunities for science teachers to serve as research assistants on college and university campuses during summer months.

FSAF will also seek financial support to conduct three or four summer conferences for science teachers similar in design to those which it has co-sponsored during the past four years. A unique outcome of these conferences has been the special reports, seven of which will have been published in *TST* by next summer.

3. Student Science Achievement Awards. This program of awards for reports of student science projects will be supported by the American Society for Metals for the seventh consecutive year. Each year has seen a significant increase in the extent of teacher and student participation. Last year, more than 27,000 sets of student materials were distributed; nearly 3000 students carried through with completed entries, and about 1100 received awards and recognition.

4. Research Grants for Teachers. This year a new program is being tried on a pilot-run basis. It will provide financial grants to secondary school science teachers to enable them to do "on-the-job research" in science or science teaching. After testing and refinement, it is hoped to expand the program through direct grants by FSAF and through cooperation with other groups or agencies with funds to make such grants.

5. Tomorrow's Scientists. This student publication will be partially supported by FSAF during 1957-58, its second year of publication. Still in the tryout stage, the goal is at least 30,000 subscriptions, which will make *TS* a self-supporting publication.

6. Guidance Materials. New editions, reprintings, or revisions of *Encouraging Future Scientists: Keys to Careers* and *Careers in Science Teaching* were authorized for 1957-58. With a distribution of more than 200,000 copies, these booklets are considered to be among the most realistic and helpful services provided by FSAF.

7. Other. This year FSAF will continue to support the revision and extension of NSTA's name list of U. S. science teachers in junior and senior high schools. It is already the most accurate and largest list of its kind; it is expected that more than 40,000 teachers will be included this year. School principals must take the responsibility to get their teachers on the list; report forms are available from NSTA.

Many of the above projects are now under way; plans are being matured to carry through on the others. To enable the full program to be carried out, industry will be asked to provide most of the necessary budget of more than $100,000. It may be that special efforts will be needed this year to raise the money. The FSAF Administrative Committee was concerned—though not dismayed—to note that FSAF general contributions for 1956-57 dropped to $27,000, compared to $36,000 for 1955-56. No conclusive inferences were drawn from this record, but participation of sponsors during 1957-58 will be watched with deep interest.

Wanted: Reports on Research

The FSAF subcommittee in charge of on-the-job research grants invites all secondary school science teachers to help in refining and developing this project. It is expected that this year's test run will reveal potential values, roadblocks, and "bugs" inherent in the underlying idea and its hypotheses. However, much more information is needed. The committee would like to hear from teachers who may already have carried out on-the-job research. This means research on scientific problems or experimental or controlled studies in

aspects of science teaching which have been carried on during the school year and in conjunction with the teacher's regular job.

If you have done things along this line, please write to the committee chairman and give him at least a brief account of your work. Be sure to cover such points as these: what you did; what sources of help you had, advisory or consultative and financial; who your co-operators were; what the attitudes were of your school administrative and supervisory staff; how you were able to find time to do the research; how you may have involved some of your students in the work; what impact or influence the work may have had on your teaching and how it affected your students; and other significant points relative to the project(s) you have carried on. Send your report to Dr. Philip G. Johnson, Stone Hall, Cornell University, Ithaca, New York.

BOOK BRIEFS

MAN AGAINST GERMS. A. L. Baron. 320p. $4.50. E. P. Dutton & Co., Inc., New York. 1957.

Story of man's struggle against 13 diseases; narrative style; interesting, informative.

SCIENCE AND HUMAN LIFE. J. A. V. Butler. 162p. $3.95. Basic Books, Inc., New York. 1957.

Erudite discussion by a leading British chemist of the impact of modern science on modern man's human qualities.

A KEY TO THE STARS. R. van der R. Woolley. 144p. $4.75. Philosophical Library, New York. 1957.

Third edition of an introduction to astronomy and astrophysics. Written for the nonspecialist in understandable terms.

ELEMENTARY SCHOOL SCIENCE: RESEARCH, THEORY AND PRACTICE. Maxine Dunfee and Julian Greenlee. 67p. $1. Association for Supervision and Curriculum Development, National Education Association, Washington, D. C. 1957.

Paperback publication reporting on key experimentation and research in the elementary science field. Includes practical data on teaching elementary science and improving the program.

BUILDING BLOCKS OF THE UNIVERSE. Isaac Asimov. 256p. $3. Abelard-Schuman, Inc., New York. 1957.

A report for young people on the 101 chemical elements known at the time of writing. Interesting, attention-holding text with pertinent history-of-science facts.

VANGUARD! Martin Caidin. 288p. $3.95. E. P. Dutton & Co., Inc., New York. 1957.

A pre-sputnik report on the U. S. program to develop a satellite.

SCIENCE AND SURGERY. Frank G. Slaughter. 272p. 35¢. Permabooks, New York. 1956.

Paperback, completely rewritten version of the author's "The New Science of Surgery." Covers a multitude of subjects ranging from shock to operations, from earliest anesthetics to medicine in the atomic age.

PHILOSOPHY OF SCIENCE. Philipp Frank. 394p. $5.75. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. 1957.

Subtitled "The Link Between Science and Philosophy." An erudite book that explores the relationship between physical theories and philosophical systems and also the distinction between a physical theory and its metaphysical interpretation.

INTRODUCTION TO CHEMISTRY. Joseph C. Muhler, Charles S. Rohrer, and Ernest E. Campaigne. 452p. $6.75. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. 1957.

A textbook designed mainly for students who plan work in some aspects of biological science but whose chemical background will be limited. The emphasis is on biochemistry. Innumerable diagrams and photographs.

CONCEPTS OF FORCE: A STUDY IN THE FOUNDATIONS OF DYNAMICS. Max Jammer. 269p. $5.50. Harvard University Press, Cambridge, Massachusetts. 1957.

An analytical examination of the role of force in classical as well as in modern physics. A book for the serious student of the philosophy of science, blending and balancing the historical, philosophical, and scientific points of view.

HOW TO KNOW MINERALS AND ROCKS. Richard M. Pearl. 200p. 50¢. Signet Key Book, New American Library of World Literature, Inc., New York. 1957.

Definitive information for one who wants to know the important gems, ores, and metals of the mineral kingdom. Profusely illustrated including 46 full color illustrations as well as drawings of each rock and mineral discussed.

THE CONQUEST OF THE ANTARCTIC. Norman Kemp. 152p. $4.75. Philosophical Library, Inc., New York. 1957.

A timely book reporting on previous expeditions to Antarctica. Good background for new knowledge to be uncovered during the International Geophysical Year. Written by a New Zealander in a readable style.

BASIC PHYSICS. Alexander Efron. 724p. $8.95. John F. Rider Publisher, Inc., New York. 1957.

A two-volume textbook in a single binding, designed to cover the fundamentals of classical and modern physics at the intermediate level. Basic demonstration experiments are described and model problems of graduated difficulty are presented. More than 800 illustrations.

RESOURCE LITERATURE FOR SCIENCE TEACHERS. John S. Richardson, Editor. 70p. $1. Lithoprinted. College of Education, The Ohio State University, Columbus, Ohio. 1957.

An annotated biobibliography to help the science teacher in search of research tools and resource literature. "The Teaching of Science" section includes listings for elementary and secondary school science teaching, also yearbooks related to science teaching, magazines and government publications, book lists. Two other major sections are titled "Readings in Science" and "Research in Science Education." An invaluable reference book for students in science education as well as science teachers.

Audio-Visual REVIEWS

MOLECULES TO MISSILES. 10 min. 1957. Color. Redstone Arsenal Research Division, Rohm & Haas Co., Huntsville, Alabama.

Recommendation: Senior high school and college freshman and sophomore physics and chemistry classes.

Content: With the theme of research, the film presents the value of, and need for, continuing study, research, experimentation, and testing. The illustrations of laboratory and research procedures and equipment are especially good.

Evaluation: Timely, well organized film with good applications illustrated throughout. In addition to conveying considerable factual information, the film should stimulate interest in research.

◆ ◆ ◆

WHAT'S A SILICONE? 32 min. 1957. Color. Dow Corning Corp. (Doan Production), Midland, Michigan.

Recommendation: General science classes at the high school level and senior high and college chemistry classes.

Content: Explaining the uses and structures of various types of silicone products, the film contains an abundance of nontechnical information on silicone, the manufacturing processes involved, and the many uses and potentialities of this product.

Evaluation: Excellent photography in a well organized and very timely film. The sound tends to fluctuate. The film should stimulate interest, reading, and experimentation.

◆ ◆ ◆

SNOWFLAKES. 8 min. 1956. B & W, Color. Moody Institute of Science, Educational Film Division, 11428 Santa Monica Blvd., West Los Angeles 25, California.

Recommendation: Third through sixth grades in general science areas.

Content: The film presents many scenes of snow and several microphotographs of snowflakes. It touches rather lightly on how snow provides water for irrigation. Fairly general in treatment, the film does not have a high scientific value.

Evaluation: Elementary in approach, the film should build attitudes but not contribute particularly to the stimulation of interest and/or reading. The color photography is beautifully done.

◆ ◆ ◆

TOADS. 10 min. 1957. $100 Color. Pat Dowling, 1056 South Robertson Blvd., Los Angeles 35, California.

Recommendation: Elementary through junior high school levels in general science areas.

Content: This film relates the life cycle of the toad, showing the transition from water to land animal, and from egg to adult. Clearly depicted are the way the toad has adapted to land life with its dangers as well as how the animal uses its specialized organs such as the eyes and sticky tongue.

Evaluation: Fine photography and very good organization. It is an appropriately developed film with much factual information. The sound could be improved.

SHELL MERIT FELLOWSHIPS

Announcing the 1958 summer fellowships program, Shell Companies Foundation, Inc. reported that 100 will be available for high school teachers of physics, chemistry, and mathematics. Fellows receive allowances for travel, tuition, living expenses, and $500 in cash to offset the loss of other summer earnings. Half the fellows will attend full summer sessions at Stanford University; the other half, at Cornell University. U. S. and Canadian teachers with at least five years' experience are eligible. The deadline for applications is February 1. Teachers living west of the Mississippi should write for fellowship applications to the School of Education, Stanford University, Stanford, California; teachers living east of the Mississippi, to the School of Education, Cornell University, Ithaca, New York.

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Similarily, Paul Brandwein, formerly of Forest Hills (New York) High School, in his book, "The Gifted Student as Future Scientist,"[8] is concerned with the development of scientists, not science prize winners—and there can be a difference.

Some of Mr. Simmons' specific suggestions carry connotations which I am sure he did not intend. Nonetheless they might be damaging to the public's concept of pupil competitions:

1. In the recruiting of potential winners, "it is desirable that these young people come from homes of at least moderate circumstances as money is needed for materials and construction tools, including a car to transport their interest-creating projects to the science fairs." This is a form of economic discrimination which would be reprehensible to science teachers. A teacher who possessed the driving energy to conduct the kind of campaign suggested by the author would find some way of overcoming the economic barrier. Happily, Mr. Simmons mitigates his statement with the note that, "In some cases, Boards of Education furnish the transportation."

2. In the selection of subject matter, "Consider timely areas such as electronics, automation, atomic energy, supersonics, and the International Geophysical Year. . . . However, if possible, allow the youngster to make his own choice." (*sic!*) Alexander Fleming, curious about the effects of molds upon his bacterial plates, would have received little encouragement from a teacher overly solicitous for timely topics.

3. "The teacher-sponsored experience should show . . . problem solving, originality and creativity, . . . (and) independent thinking." But "Students and parents should invite qualified people to their homes for suggestions and improvements." These two statements indicate an incompatability which requires further comment.

Certainly pupils should seek assistance in solving their problems—practicing scientists do. But there is the question of the degree of outside help. I think judges should prefer crude work which is original rather than polished exhibits succored by "qualified people." (I do not mean now to inaugurate a new trend for getting expert help in roughening-up exhibits.) I do not know that there is any answer to the delicate problem of judging the extent of individual work in a project, but the practice of devising a campaign for producing winners by the deliberate scheduling of visits by outside experts seems to be going too far. I commend the practice of some recognition programs which ask pupils to state the extent of outside help they received.

4. "From the cumulative evidence, there appears to be many more quality entries from (the) physics field. Chemistry seems to be less competitive." This would imply that teachers should guide pupils away from their interests toward areas where there is a good chance of winning. Fortunately, the author adds, "To be realistic and meaningful, projects should have a personal interest origin."

It is good to observe that Mr. Simmons' concluding paragraph refers to the goals of creativity and critical thinking. I am sure that these are his objectives while working with students and that the connotations which I have attempted to dispel represent inadequacies in semantics rather than in educational philosophy.

[8] Brandwein, Paul: *The Gifted Student as Future Scientist.* Harcourt, Brace and Co., 1955.

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